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ORIGINAL ARTICLES.

I.—Footprints of Vertebrates in the Coal-measures of Kansas.

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(PLATE XI.)

THE Museum of Yale University contains a small collection of footprints of much interest, which were found in 1873, in the Middle Coal-measures, near Osage, in South-eastern Kansas. A careful re-examination of these footprints has been recently made by the writer, and the main results are given in the present paper.

The impressions are well preserved in a calcareous shale, which separates readily into thin slabs, each representing a surface of the beach at the time the footprints were made upon it. A few shells in the shale are sufficient to prove that the formation is marine. Trails of annelids, and perhaps of other invertebrates, are seen on some of the surfaces. The footprints of vertebrate animals, however, are of paramount importance, and the large number and variety of these here recorded on a single surface, if they could be rightly interpreted, would form an interesting chapter of land vertebrate life in the Carboniferous period, about which so little is at present known.

On Plate XI., accompanying the present article, five distinct series of footprints are shown, each one-twelfth natural size. All were found on essentially the same surface, and at one locality. The five different animals they represent were thus contemporaries, and indicate a wealth of air-breathing vertebrate life at this period, hitherto unsuspected.

With these impressions were still others, made either by animals nearly allied, or by the same animals under different circumstances. These need not be further noticed in this connection, but they serve to emphasize the diversity of life at this point. The typical series are briefly described below.

Nanopus caudatus. Pl. XI. Fig. 1.

The first series represented on Plate XI. Fig. 1 indicates the smallest animal that here left a distinct series of footsteps, and the only one in which an imprint made by the tail was preserved. This small quadruped had evidently but three functional toes on the

fore feet, and four on those behind. The fore feet were considerably smaller than the hind feet. The impressions made by the latter are nearly all separate from the anterior footprints, although at times slightly overlapping them.

The nature of the animal indicated by these impressions can at present be a matter of conjecture only, but the probabilities are in favour of its reference to the Amphibians rather than to the true *Reptilia*. As it is evidently distinct from anything hitherto described, the above name is proposed for it.

Limnopus vagus. Pl. XI. Fig. 2.

In Fig. 2, Plate XI., a second series of footprints is represented, somewhat larger than those above described, and evidently made by a very different animal. The front feet had four functional toes, while those behind had five, all well developed. The impressions of the hind feet, as a rule, overlap those of the corresponding fore feet. No indications of a tail can be detected. In length of stride, and in the distance between the footsteps of the right and left sides, the present series is proportionately about the same as those above described, although the animals differed much in size. They were probably both Amphibians, and may have been nearly allied.

Dromopus agilis. Pl. XI. Fig. 3.

The third series of footprints shown on Plate XI. Fig. 3 is of special interest, and indicates an animal very distinct from the two already described.

A striking feature in the fore and hind feet of this animal was the long, slender digits, terminated by sharp claws. Another point of interest, as recorded in the footprints, is that the animal in walking swung the hind feet outward, and so near the ground that the ends of the longer toes sometimes made trails in the mud, marking accurately the sweep of the foot. This would seem to indicate a comparatively short hind leg, rather than the long slender one which the footmarks themselves naturally suggest.

The animal that made these interesting footprints was probably a Lacertilian rather than an Amphibian, but there is also a possibility that it was a primitive Dinosaur.

Allopus littoralis. Pl. XI. Figs. 4, 4*a*.

Besides the footprints above described, which pertain to animals of comparatively small size, there are several other series in this collection made by very large animals, which were probably all Labyrinthodonts. These tracks were made on the same beach, and at about the same time, as the small footprints, but not all under the same circumstances. The largest animal thus represented appears to have walked on one part of the beach that was quite firm, leaving very shallow footprints, and again to have traversed another part, quite near the first, but slightly covered with water, or at all events so soft that deep impressions were made by the feet, while the toes

of the hind feet also left deep trails as they swung outward at each step. On Plate XI. Figs 4 and 4*a* these two kinds of footprints are represented. They show the stride of the animal, and, as put together, also denote the width between the footprints of the two sides, so that the series can be compared with the others on the same plate.

These tracks show that the animal had five toes in the fore feet and four behind. The hind feet show a distinct impression of a sole. There is no imprint of a tail, even where the mud appears to have been deep.

Baropus lentus. Pl. XI. Fig. 5.

The most abundant of the large footprints are represented by several series, which are remarkably uniform in stride and in width between the right and left rows. One of these series is represented on Plate XI. Fig. 5, and this is typical of the others. The animal that made these footprints evidently had four functional toes in front and the same number behind. On the inner side of each foot, however, there was a projection, which, in the hind feet, was quite prominent and characteristic, but can hardly be interpreted as the imprint of the first digit. Nearly all these footprints show a distinct impression of a sole. This is usually faint in the tracks of the fore feet, but strongly marked in those behind.

It is hardly necessary at this time to attempt a detailed comparison of the footprints above described with those already on record. The present specimens all have well-marked characters, and, being from a single horizon and locality, have a value of their own as throwing light on the land vertebrate life, during the deposition of the true Coal-measures. If, in themselves, they add but little to what is already known, they at least offer encouragement to investigators in an interesting field not yet systematically explored. The publications of Logan, Lyell, King, Lea, Dawson, and others have already made known discoveries of importance in this country, and others have been recorded in the Old World.

So far as at present known, land vertebrate life began in the Carboniferous age, no footprints or other remains of this kind having been detected below the sub-Carboniferous. That such remains will eventually be found in the Devonian, there can be no reasonable doubt, and perhaps even in the Silurian, if the land surfaces then existing can be explored.

EXPLANATION OF PLATE XI.

FIG. 1.—Series of footprints of *Nanopus caudatus*, Marsh; showing, also, impression made by the tail.
,, 2.—Series of footprints of *Limnopus vagus*, Marsh.
,, 3.—Series of footprints of *Dromopus agilis*, Marsh; showing trails made by the toes.
,, 4.—Two pairs of footprints of *Allopus littoralis*, Marsh; right side.
,, 4*a*.—Footprints of same; showing trails made by the toes; left side.
,, 5.—Series of footprints of *Baropus lentus*, Marsh.

All the figures are one-twelfth natural size.

II.—Pleistocene Climatic Changes.[1]

By Warren Upham, F.G.S.A.

THE most interesting and difficult climatic problem presented in all the geologic record is that of its latest period, immediately preceding the present, to discover the causes, first, of the accumulation, and later, of the rapid final melting of its vast sheets of land-ice. The fossil floras of Greenland and Spitzbergen indicate that those far northern latitudes enjoyed a temperate climate in the Miocene period; and, from the absence of glacial drift through the great series of Tertiary and Mesozoic formations, we infer that climates as mild as those of the present day had prevailed during long eras before the Ice-age. With suddenness, geologically speaking, there came during the Quaternary era a very exceptional and unique period of great refrigeration of the climate of northern regions, overwhelming the Siberian herds of Mammoths, and covering the surface of the northern half of North America and of North-Western Europe with snow and ice which increased to thousands of feet in depth. The conditions that seem requisite for the formation of these ice-sheets are long-continued rather than excessive cold and an abundant supply of moisture by storms, giving plentiful precipitation of snow during more of the year than now, so as to include in the time of snow accumulation not only the present winter but also the autumn and spring months. The summers, too, were probably cooler than now, for their heat was not sufficient to melt away the accumulated snow, which gradually increased in thickness from year to year, its lower part being changed to ice. When large portions of continents became thus ice-covered, the storms sweeping over them would be so rapidly cooled that the greater part of their snowfall would take place upon the borders of the ice-sheet, within probably fifty to two hundred miles from its margin; but the snowfall during the advance of the ice was probably in excess of the amount of evaporation and melting over the whole of the ice-covered areas.

Upon British America and in the northern part of the United States the directions of the glacial striæ and transportation of the drift show that there were two general ice-sheets—one reaching from New England, Nova Scotia, Newfoundland, and Labrador west to the Rocky Mountains, and north to the Arctic Ocean, having its greatest thickness over the Laurentide Highlands and James Bay, with outflow thence to the east, south, west, and north; and the other west of the Rocky Mountains, covering British Columbia, attaining a maximum thickness of about one mile, and outflowing south into the United States, west into the Pacific Ocean, and northward into the upper part of the Yukon Basin. These ice-sheets, named by Dr. George M. Dawson the Laurentide and Cordilleran, are shown, by the characters of the drift deposits along the eastern

[1] Presented at the World's Congress on Geology, auxiliary with the Columbian Exposition in Chicago, August 26th, 1893.

side of the Rocky Mountains, to have become confluent at their time of maximum thickness and extent. The Cordilleran outflow, pouring eastward through passes of these mountains, and in the Peace River region probably overtopping the highest summits, which there are only about 6000 feet above the sea, pushed across a narrow belt adjoining the mountains, to a maximum distance of nearly 100 miles, and there (on land about 2500 feet above the sea) was merged with the Laurentide ice, the two united currents thence passing in part to the south and in part to the north from the interior tract, where the confluent ice was thickest. When the Glacial period reached its culmination, nearly all the northern half of this continent, excepting Alaska, was thus enveloped by a continuous sheet of land-ice which stretched from the Atlantic to the Pacific, and from the Ohio and Missouri Rivers to the Arctic Archipelago, having an approximate area of 4,000,000 square miles.

Almost half as large an area was ice-covered in Europe, with the basins of the Irish, North, Baltic, and White Seas, the principal centre of outflow being the plateau and mountains of Scandinavia, whence the ice moved west and north into the Atlantic, southward over Northern Germany, and eastward over a large part of Russia. Smaller ice-sheets were formed upon Scotland and Ireland, and these became confluent with each other and with the Scandinavian ice which outflowed to the borders of Great Britain. Glaciers also were far more extensive than now in the Alps, Pyrenees, Caucasus, and Himalayas; but Northern Asia seems to have had no general ice-sheet. The most anomalous feature in this strange accumulation of ice was its absence from the greater portions of Siberia and Alaska, while so heavily massed in the same and more southern latitudes of British America, the Northern United States, the British Isles, and North-Western Europe.

Both the growth and the decline of the ice-sheets were attended by considerable fluctuations of the ice-border, which appear to have been due to secular changes of moderate amount in the average climatic conditions of temperature and precipitation of snow and rain. Comparatively few records, however, of the glacial fluctuations during the time of general advance and culmination are preserved, since the drift deposits of those stages are mostly covered, unless they suffered glacial erosion and were thus wholly lost, beneath the deposits of later drift which tell the vicissitudes of the general retreat and departure of the ice.

Evidence of important glacial recession and re-advance in North America, separated by centuries or probably thousands of years, has been obtained only in the great interior expanse of the Mississippi basin. Mr. Frank Leverett[1] has reported there, in Southern Illinois, Indiana, and Ohio, sections showing an old surface of Till, deeply buried by the Till of another ice advance, which extended far south of the retreatal moraines and on some areas formed the extreme glacial boundary. The soil and the oxidized and leached

[1] Proceedings of the Boston Society of Natural History, vol. xxiv. pp. 455–459, January 1st, 1890.

subsoil of the buried Till have been examined carefully by Mr. Leverett, who finds that the large proportion of glacially eroded limestone detritus which characterizes both these Tills had been wholly dissolved away from the buried subsoil, before its envelopment by the ensuing ice advance, to a depth of several feet, equalling or exceeding the depth of such leaching in the Till subsoil at the present surface. He therefore concludes that an interval of time at least approximately equal to the duration of the post-Glacial epoch had elapsed between the retreat and re-advance of the ice in that district close to the limits of the Drift. Further, very impressive testimony of this long interval is afforded in the valleys of the Ohio river and its tributaries by the great amount of erosion of the early stratified drift gravel and sand which had taken place, cutting the valleys from the highest terraces to the present river-beds or deeper, before the formation of the retreatal moraines and the accompanying low valley-drift deposits. The climatic changes, and the resulting two advances of the ice-border, which are thus recorded, probably belonged to the later part of the time of general growth of the ice-sheet. The extent of the intervening retreat appears to have been 100 to 250 miles in portions of the Mississippi basin; but it was doubtless much less, as perhaps only a few miles, or may have been mainly wanting, in New York, Pennsylvania, New Jersey, and New England, for there no observations of similar significance have been reported.

During the general recession of the ice-sheet abundant deposition of Loess took place in the Mississippi and Missouri basins. The observations of Prof. R. D. Salisbury, Mr. W. J. McGee, and the present writer show, respectively, that the Loess was being laid down contemporaneously with the retreat of the ice (1) in Southern Illinois and Indiana, on the borders of the Drift; (2) in North-Eastern Iowa, between the driftless area of Wisconsin and the retreatal moraines; and (3) in North-Western Iowa, adjacent to and accompanying the accumulation of the outermost moraine and the late drift which it encloses.

Beginning with this first or Altamont moraine, I have traced a series of twelve approximately parallel moraine belts, succeeding one another from south to north, in North Central Iowa, Minnesota, North Dakota, and Manitoba, of which a Map for the State of Minnesota is presented in Wright's "Ice-Age in North America" (page 546). A still larger number of retreatal moraines, up to fifteen or twenty, has been found by Mr. Leverett in the country north of the Ohio river; and Prof. T. C. Chamberlin has mapped the course of the principal outer moraines from the Atlantic coast across a distance of 1500 miles to North Dakota.[1]

Contemporaneous with the formation of the most northern five moraines explored in Minnesota, the glacial lake Agassiz was held in the basin of the Red River of the North and of Lake Winnipeg by the barrier of the receding ice-sheet; but these moraines, each

[1] United States Geol. Survey, Third Ann. Rep. for 1881–82, pp. 291–402, with 10 plates.

comprising portions which rise in hills 150 to 200 feet high, all belong to the southern third or half of the entire extent of Lake Agassiz, and probably also to the first third or half of its entire duration. When the forest-covered and almost uninhabited country northward shall be fully explored, probably the number of moraines ascertained to have been formed during the existence of this glacial lake will be at least doubled. Growing from south to north as the barrier of the continental glacier retreated, Lake Agassiz attained a length of about 700 miles, and an area of not less than 110,000 square miles, exceeding the combined areas of the great lakes outflowing by the St. Lawrence; and its depth above Lake Winnipeg was about 600 feet.

If now the question be asked how many thousand years ago did the recession of the ice-sheet take place, producing Lake Agassiz, and at halts or slight stages of re-advance forming the moraines, a reply is furnished by the computations of Prof. N. H. Winchell,[1] that approximately 8000 years have elapsed during the erosion of the post-Glacial gorge of the Mississippi from Fort Snelling to the Falls of St. Anthony; of Dr. Andrews,[2] that the erosion of the shores of Lake Michigan, and the resulting accumulation of dune sand drifted to the southern end of that lake, cannot have occupied more than 7500 years; of Prof. G. Frederick Wright,[3] that streams tributary to Lake Erie have taken a similar length of time to cut their valleys and the gorges below their water-falls; of Mr. G. K. Gilbert,[4] that the gorge below Niagara Falls has required only 7000 years, more or less; and of Prof. B. K. Emerson,[5] on the rate of deposition of modified drift in the Connecticut Valley at Northampton, Massachusetts, from which he believes that not more than 10,000 years have elapsed since the Glacial period. An equally small estimate is also indicated by the studies of Gilbert[6] and Russell[7] for the time since the last great rise of the Quaternary Lakes Bonneville and Lahontan, lying in Utah and Nevada, within the arid Great Basin of interior drainage, which are believed to have been contemporaneous with the great extension of land-ice upon the northern part of the North American continent. These measures of time, surprisingly short, whether we compare them on the one hand with the period of authentic human history, or on the other with the long record of geology, carry us back to the date when the ice-sheet

[1] Geology of Minnesota, Fifth Annual Report, for 1876; and Final Report, vol. ii. 1888, pp. 313–341. Quart. Journ. Geol. Soc. vol. xxxiv. 1878, pp. 886–901.

[2] Trans. Chicago Academy of Sciences, vol. ii. James C. Southall's Epoch of the Mammoth and the Apparition of Man upon the Earth, 1878, chapters xxii. and xxiii.

[3] Amer. Journ. Science, iii. vol. xxi. pp. 120–123, February, 1881; The Ice-Age in North America, 1889, chapter xx.

[4] Proc. Amer. Assoc. for Advancement of Science, vol. xxxv. for 1886, p. 222. "The History of the Niagara River," Sixth Ann. Rep. of Commissioners of the State Reservation at Niagara, for 1889, pp. 61–84.

[5] Amer. Journ. Science, iii. vol. xxxiv. pp. 404–5, November, 1887.

[6] United States Geol. Survey, Second Annual Report, for 1880–81, p. 188; Monograph I. Lake Bonneville, 1890, chapter vi.

[7] United States Geol. Survey, Monograph XI. Geological History of Lake Lahontan, 1885, p. 273.

was melting away from the basins of the Upper Mississippi, of the northern Red River, and of the Laurentian lakes.

The entire departure of the North American ice-sheet, therefore, probably occupied only two or three thousand years; and half of this time may measure the duration of Lake Agassiz, with the accumulation of the numerous adjacent moraines whose courses intersect the lake area, and with the formation of its beaches marking about thirty successive stages in the concurrent subsidence of the lake surface and rise of the earth's crust, which amounted together to 700 feet on the latitude of the north part of Duck Mountain and the middle of Lake Winnipeg. But even these short estimates may be too long. The shores of Lake Michigan, similar with those of Lake Agassiz, in the Drift of which they are formed, in their north and south trends and in the adjoining depths of water, have suffered an amount of erosion by the lake waves during post-Glacial time which very far exceeds the total erosion that was effected upon the shores of Lake Agassiz during all its stages, the proportion between them being surely not less than ten to one; and Lake Michigan has a similarly greater amount of beach deposits, which upon a large area about its south end are raised by the wind in conspicuous dunes. This contrast, indeed, suggests that the duration of Lake Agassiz, and the recession of the ice-sheet from its area and from the greater part of the area of Hudson Bay, may have been included within less than one thousand years.[1]

Having thus reviewed the Glacial period, we come to inquire—What were the causes of its grand climatic changes, leading first to the accumulation, and then to the rapid departure, of the ice-sheets? Upon their areas warm or at least temperate climates had prevailed during long foregoing geologic ages, and again at the present time they have mostly mild and temperate conditions. The Pleistocene continental glaciers of North America, Europe, and Patagonia have disappeared; and the later and principal part of their melting was very rapid, as is known by various features of the contemporaneous glacial and modified drift deposits and by the beaches and deltas of temporary lakes that were formed by the barrier of the receding glaciers. Can the conditions and causes be found which amassed the thick and vastly extended sheets of land-ice, and whose cessation suddenly permitted the ice to be quickly melted away?

Two principal theories of the causes of the Ice-age seek to answer these inquiries. The one which we will first consider is the astronomic theory of Croll, Geikie, and Ball. In accordance with Dr. Croll's theory, Glacial periods would be expected to recur with geologic frequency, whenever the earth's orbit attained a stage of maximum eccentricity, during the very long Tertiary and Mesozoic eras, which together were probably a hundred times as long as the Quaternary era in which the Ice-age occurred. But we have no evidence of any Tertiary or Mesozoic period of general glaciation in circumpolar and temperate regions, although high mountain groups or ranges are

[1] Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, vol. iv. for 1888–89, pp. 50, 51 E.

known to have had local glaciers. Not until we go back to the Permian period, closing the Palæozoic era, are numerous and widely distributed proofs of very ancient glaciation encountered. Boulder-bearing deposits, sometimes closely resembling Till and including striated stones, while the underlying rock also occasionally bears glacial grooves and striæ, are found in the Carboniferous or more frequently the Permian series in Britain, France, and Germany, Natal, India, and South-Eastern Australia. In Natal the striated glacier floor is in latitude 30° south, and in India only 20° north, of the Equator. During all the earth's history previous to the Ice-age, which constitutes its latest completed chapter, no other such distinct evidences of general or interrupted and alternating glaciation have been found; and just then, in close relationship with extensive and repeated oscillations of the land, and with widely distant glacial deposits and striation, we find a most remarkable epoch of mountain-building, surpassing any other time between the close of the Archæan era and the Quaternary. Mr. Alfred Russel Wallace therefore concludes that eccentricity of the earth's orbit, though tending to produce a Glacial period, is insufficient without the concurrence of high uplifts of the areas glaciated. He thinks that the last time of increased eccentricity, 240,000 to 80,000 years ago, was coincident with great altitude of North-Western Europe, North America, and Patagonia, which consequently became covered by ice-sheets; but that such previous times of eccentricity, not being favoured by geographic conditions, were not attended by glaciation. The recentness of the Ice-age, however, which has now become generally recognised and accepted by glacialists, seems to demonstrate that eccentricity was not the primary cause of glaciation, and to bring doubt that it has exerted any determining influence in producing unusual severity of cold either during the Pleistocene or any former period.

The alternative theory, which is accepted in this discussion as an explanation of the climatic conditions bringing on and carrying off the ice-sheets, has been thought out and formulated by Dana,[1] Le Conte,[2] Wright,[3] and the present writer[4] in America, and by Jamieson[5] in Scotland. On account of its referring the cold and snowy climate of the time of ice accumulation to high uplifts of the glaciated

[1] James D. Dana, Presidential Address, Proc. Amer. Assoc. for Adv. of Science, vol. ix. for 1855, pp. 23–29; Trans. Conn. Acad. of Arts and Sciences, vol. ii. 1870; many papers in the Amer. Journ. of Science; and the several editions of his Manual of Geology.

[2] Joseph Le Conte, Bulletin Geol. Soc. of America, vol. ii. 1891, pp. 323–330; Elements of Geology, third edition, 1891, p. 589.

[3] G. Frederick Wright, The Ice-Age in North America, 1889, chapter xix.; Man and the Glacial Period, 1892, chapter ix.; Amer. Journ. of Science, third series, vol. xlvii. pp. 184–187, March, 1894.

[4] Warren Upham, Appendix of the Ice-Age in North America, pp. 573–595; Amer. Journ. of Science, iii. vol. xlvi. pp. 114–121, August, 1893; Bulletin Geol. Soc. of America, vol. v. 1894, pp. 87–100; Geol. Mag. Dec. III. Vol. VII. pp. 492–497, November, 1890.

[5] Quart. Journ. Geol. Soc. vol. xviii. 1862, p. 180; vol. xxi. 1865, p. 178; Geol. Mag. Dec. II. Vol. IX. pp. 400–407 and pp. 457–466, Sept. and Oct. 1882; Dec. III. Vol. IV. pp. 344–348, August, 1887; and Dec. III. Vol. VIII. pp. 387–392, September, 1891.

regions, this may be properly named the epeirogenic theory of the Ice-age.[1] Condensed into a single paragraph, it shows in the fjords and submarine continuations of river valleys a proof that the drift-bearing areas immediately before the accumulation of the ice-sheets had been gradually elevated thousands of feet, until finally the cool plateau climate at the culmination of the uplift brought on the Glacial period; in the low condition of the lands, when the Drift was left by the retreat of the ice, it sees that these areas had sunk beneath their ice-weight, until mostly they stood somewhat below their present level; and in the post-Glacial uplift of the marine Champlain deposits, overlying coastal portions of the Glacial drift, it sees an effort of the earth to regain a state of simple flotation of the crust on the heavier mobile interior which is capable of flow whether it be solid or molten.

The epeirogenic movements of the countries which became glaciated were only a portion of widespread oscillations of continental areas during the closing part of Tertiary time and the ensuing much shorter Quaternary area. Not only were the northern half of North America and the north-western part of Europe uplifted 1000 to 3000 feet or more, but probably all the western side of Europe and Africa shared in this movement, of which we have the most convincing proof in the submerged channel of the Congo, about four hundred miles south of the Equator. From soundings for the selection of a route for a submarine cable to connect commercial stations on the African coast, Mr. J. Y. Buchanan[2] found this channel to extend eighty miles into the ocean to a depth of more than 6000 feet. The last twenty miles of the Congo have a depth of from 900 to 1450 feet. At the mouth of the river its width is three miles and its depth 2000 feet. Thirty-five miles off shore the width of the submerged channel or cañon is six miles, with a depth of about 3450 feet, its bottom being nearly 3000 feet below the sea-bed on each side. Fifty miles from the mouth of the river the sounding to the submarine continental slope is nearly 3000 feet, while the bottom of the old channel lies at 6000 feet. This very remarkable continuation of the Congo Valley far beneath the sea-level is like those of the Hudson and St. Lawrence rivers, and like numerous submerged valleys on the coast of California; but the Congo reaches to a greater depth than those of North America, and even exceeds the Sogne fjord, the longest and deepest in Norway, which has a maximum sounding of 4080 feet. Another deep submarine valley, called the "Bottomless Pit," having soundings of 2700 feet, is described by Buchanan on the African coast 350 miles north of the Equator, and he states that a similar valley exists in the southern part of the Bay of Biscay. These observations show that within very late geologic time probably almost the entire

[1] The terms *epeirogeny* and *epeirogenic* ("continent-producing," from the Greek *epeiros*, a mainland or continent) are proposed by Mr. G. K. Gilbert in his U.S. Geol. Survey Monograph, Lake Bonneville (1890), to designate the broad movements of uplift and subsidence which affect the whole or large portions of continental areas or of the oceanic basins.

[2] Scottish Geographical Magazine, vol. iii. 1887, pp. 217–238.

Atlantic side of the eastern continent has been greatly uplifted, attaining as high an altitude as that which Sir A. C. Ramsay and James Geikie conjectured as a possible cause of the frost-riven limestone-agglomerates of Gibraltar.[1]

Wherever great movements of land elevation have taken place in high latitudes, either north or south, which received abundant precipitation of moisture, ice-sheets were formed; and the weight of these ice-sheets, as was first pointed out by Jamieson, seems to have been a chief cause, and often probably the only cause, of the subsidence of these lands and the disappearance of their ice. Though the still high surface of the greater part of an ice-sheet would not be affected by the temperate climate of the country depressed to its present level or slightly lower, the warm summers along the ice-border would cause it to be rapidly melted, and by the extension of this process inward all the ice-sheet would disappear. When the progress of the marginal melting in the Mississippi basin had given generally steep gradients to the ice-front, its more powerful currents formed the retreatal moraines and the many lake basins of the unevenly laid later drift which are so strongly contrasted with the smooth and attenuated outer portion of the drift-sheet beyond the moraines.

What were the original sources of the energy displayed in the earth-movements of uplift preceding glaciation, and why this has been so extensively developed during the Quaternary era, are very difficult questions which it is not the purpose of this paper to consider, since I have attempted elsewhere to answer them, in an appendix of Wright's "Ice-Age in North America." It may be properly noted, however, that the explanations mentioned are entirely consistent with Dana's teaching that the great continental and oceanic areas have been mainly permanent from very early geologic times.

The chief objection urged against this explanation of the causes of the Glacial period and its sudden end consists in an approximate identity of level with that of to-day having been held by some drift-bearing areas at a time very shortly preceding their glaciation. This is clearly known to have been true of portions of Great Britain and of New England. In respect to this objection, it must be acknowledged that the pre-Glacial high elevation which these areas experienced was geologically very short. With the steep gradients of the Hudson, of the streams which formed the now submerged channels on the Californian coast, and of the Congo, these rivers, if allowed a long time for erosion, must have formed even longer and broader valleys than the yet very impressive troughs, continuing to depths of 2000 to 6000 feet beneath the sea-level, which are now found on these submarine continental slopes. But the duration of the epeirogenic uplift of these areas on the border of the glaciation for the Hudson, beyond it for the Californian rivers, and near the Equator in Western Africa, can scarcely be compared in its brevity with the prolonged high altitude held

[1] Quart. Journ. Geol. Soc. vol. xxxiv. 1878, pp. 505-541.

during late Tertiary and early Quaternary time by the Scandinavian peninsula, and by all the northern coasts of North America from Maine and Puget Sound to the great Arctic Archipelago and Greenland. The abundant long and branching fjords of these northern regions, and the wide and deep channels dividing the many large and small islands north of this continent, attest a very long time of high elevation there. At the time of culmination of the long-continued and slowly increasing uplifts at the north, they seem to have extended during a short epoch far to the south, coincident with the formation of ice-sheets in high latitudes. But when these lands became depressed, and the ice burden of the glaciated countries was removed, they, in some instances, as in Great Britain and New England, returned very nearly to their original levels, beautifully illustrating the natural condition of equilibrium of the earth's crust before referred to, which Dutton has named *isostasy*, that when not subjected to special and exceptional stresses it acts as if floating on a heavier plastic or molten interior.

The wane and departure of both the North American and European ice-sheets have been marked by many stages of halt and oscillation, whereby the flora, including forest trees, and less frequently traces of the fauna, of the temperate areas adjoining the melting and mainly receding ice were covered by its drift at the times of temporary re-advance of the ice-border. No better illustration of conditions favourable for the burial of forest beds in the Drift can be imagined than those of the Malaspina glacier or ice-sheet, between Mount St. Elias and the ocean, explored by Russell in 1890 and 1891, and found to be covered on its attenuated border with drift which supports luxuriant growing forests. Let a century of exceptional snowfall cause a thickening and re-advance of that ice-sheet, and sections of its drift exposed after the glacial recession will show a thick forest bed of chiefly or wholly temperate species. Such re-advances of the continental ice-sheets, interrupting their retreat, are known by well-marked recessional moraines in both North America and Europe. Near the drift boundary in the Mississippi basin some of these glacial fluctuations have involved long stages of time, measured by years or centuries, with important though minor changes in altitude, as shown by the excellent analytic studies of Chamberlin, Salisbury, McGee, and Leverett; but farther north, as in the large region of the glacial lake Agassiz, the withdrawal of the ice-sheet and formation of successive moraines marking slight halts and re-advances due to secular changes in temperature, humidity, and snowfall, were demonstrably very rapid, the whole duration of this glacial lake being probably only about 1000 years. The vicissitudes of the general glacial retreat seem to me to have been due thus chiefly to variations of snowfall, some long terms of years having much snow and prevailingly cool temperature, therefore allowing considerable glacial re-advance, while for the greater part other series of years favoured rapid melting and retreat.

Under this view we may, I think, account for all the observations which have been held in America and Europe as proofs of inter-

Glacial epochs, without assuming that there was either any far re-advance of the ice-border or any epeirogenic movements attending the glacial retreat of such magnitude as to induce the fluctuations of which the forest beds and marginal moraines bear witness. Though the whole history of the growth, culmination, and departure of the ice-sheets is indeed very complex and long, as measured by our familiar historical time units, it was yet, in my opinion, geologically very brief if compared with all preceding geologic periods and epochs. Instead of being subdivided by long intervals of temperate or warm climate, the Ice-age seems to me to have been essentially continuous and single, with important fluctuations, but not of epochal significance, both during its advance and decline.

III.—Notes on Russian Geology.

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(*Continued from the July Number*, p. 312.)

III. The Black Earth.

Prof. Krasnov states that the decomposition of the roots of plants gives rise to the humus, but attaches much more importance to the effect of climatic conditions. Thus, he remarks, "that it is impossible not to note that the Tchernozem occupies a band stretching from S.W. to N.E., that is, the position where the influence of a temperate and moist climate ends, and the region of dry S.E. winds begins. In the N. and N.W. of Russia the woods predominate, unless destroyed by man, or prevented by the marshy nature of the country. Where Black Earth begins, the woods end, and little by little steppe assumes sway, first as half steppe (that is to say, the alternation of wood and broad black earth plains), and finally to the S. as true steppe, where the view is, in most cases, unimpeded even by a single bush."

Prof. Dokoutchaieff has recently discussed the whole of this question ("The Russian Steppes": a pamphlet written for the World's Columbian Exhibition at Chicago, 1893). He shows that in the N. of the Poltava government the outlines of the steppe and forest boundaries are clearly marked out, and that it is yet possible to trace the positions formerly occupied by extensive forests, by means of the special character of the soil to which they have given rise.

He has also shown that there is a transitional structure in the Black Earth itself. In some of the Eastern governments (Tambov, Penza, Simbirsk, and Samara in part) a maximum humus percentage of 12 per cent. is attained, whilst to the N.W. and S.E. of these the quantity of humus diminishes.

Accordingly he concludes that to the N.W. the superabundance of moisture, and to the S.E. the dryness, prevent the formation of humus, and that it is in the transitional climatic band that the most favourable conditions for its production exist. I am not aware that any chemical research has been carried out on Black Earth soils

hailing from districts south of the Poltava government. Such a research could not fail to be of great interest, when compared with the results already obtained by students of the problems of Central Russian agriculture.

Prof. Krasnov holds the same views, and claims that they are materially confirmed by the fact that in Turkestan, the Crimea, the Caucasus, and America the transition districts between the dry steppe and moist forest-land, under climatic influences resembling those of South Russia, possess soil structures similar to the Black Earth, and present the same phases in their alternation. In addition the flora can be readily paralleled with those of the steppe itself.

The original virgin steppe is fast disappearing before the advance of cultivation. Nevertheless, here and there a few traces of its original characters are preserved. The typical forms are *Stipa pennata*, *Stipa capillata*, *Campanula Sibirica*, *Falcaria Rivini*, and *Gypsophila paniculata*. At a point in the south of the Poltava government, *Amygdalus nana* and *Prunus chamœcerasus* form low-growing but impenetrable bushes, so that it is evident that the present conditions are but a poor indication of the wealth of vegetation which once covered these plains (Dokoutchaieff, *loc. cit.*). The cultivation above-mentioned has, no doubt, wielded an enormous influence in the production of those serious changes which are causing such anxiety to Russian agriculturists. The virgin steppe easily sucked up the atmospheric moisture which fell upon its surface, whereas on the ploughed land the rain-water collects in the form of minor torrents, sweeps away the rich earth, carrying it down into the river valleys and alluvial flats. The result is very noticeable along the banks of the Dnieper during the summer-time, a distinctly-marked Black Earth forming a conspicuous object in the low cliffs which skirt the river for many miles. In addition, the Black Earth is much more liable to redistribution by æolian action, every breath of wind tending to carry away a small cloud of dust with it. This may be easily proved by direct observation, the traveller who crosses the steppes having his face blackened on the side which is windward, whereas the other remains perfectly clean.

This movement has only one result, viz. that the Black Earth is moved from one steppe to another, excepting where it meets with some obstacle, or is carried outside the plain region altogether. Far more destructive has been the forest denudation in the higher reaches of the river, the flooded waters, having lost the check which formerly kept them in bounds, carrying away the rich soil without offering any compensating advantage. This destruction, due to human agency, is in strong contrast to the gradual and natural advance of trees into the steppe area, an advance which is in close connection with the denudation of that area.

It has been pointed out by students of forestry in Russia that the woods on the steppe are of two classes: 1st, Conifers, represented mostly by firs; and 2nd, the leafy (deciduous) trees, principally oak, ash, birch, and hornbeam. The Conifers generally form forests, often of considerable extent, which occupy the alluvial plains of

the great rivers, growing exclusively on sands and other fluviatile deposits. The woods which form such conspicuous backgrounds to the views obtainable from Kieff and Sviati-Gori, over the valleys of the Dnieper and Donetz respectively, are of this nature.

Nevertheless, at the latter locality, occurs an exception which appears to be of the greatest interest. D. J. Litwinoff (Moscow Bull. Sept. 1891) has called attention to the fact that on the chalk escarpment, which forms so prominent a feature at Sviati-Gori, and at other points along the Donetz, is one of the very few occurrences of *Pinus silvestris* known in S. Russia. Accompanying it is a great variety of flowers, all of which have a distinct Alpine character. The whole evidence seems to prove that these plants were already living here at far earlier geological epochs, and that this small remnant had been preserved during all the vicissitudes and changes of Pleistocene history.

On the other hand, the deciduous leaved trees cling to the sides of the balkas and smaller streams, such as the Kalmiuss, and also clothe the sides of the high right banks of the rivers already referred to. Professor Krasnov points out "that the forests appear to avoid the level steppes open to the influences of the winds. There are, however, numerous exceptions. High watersheds, cut into deep ravines, and balkas are generally wooded; thence the vegetation extends down the water-courses, in a band which comes closer to the stream as the latter reaches more level regions, less cut into by ravines and fissures. As researches have shown in the Poltava government, the grey wood-soil follows the same law of extension. This law has received but slight attention on the part of students of soils." Professor Dokoutchaieff also lays stress on the fact that as fissures are formed, going over into ravines or valleys of rivers, woods hasten to occupy them, and thus are gradually invading S. Russia.

Professor Kostitch on his side argues along the lines adopted by Professor Whitney for the United States. He holds that the law of the extension of forests depends upon the structure of the watersheds. The rains carry away the fine particles, leaving a coarse-grained undersoil. The relations of coarse and fine-grained soils to the absorption of rain-water are very different. In the former case the water quickly descends into the deeper parts, and is retained there for a long time, before it evaporates. On the contrary, the fine-grained soil holds all the moisture at the surface, and allows it with difficulty to penetrate. The lower-lying substratum, even after strong rains, remains dry, while the upper is turned to mud. From such a surface the moisture, under the influence of dry winds, soon evaporates.

On these foundations Professor Kostitch builds his wood-extension theory. He believes that in the steppes the only places where trees would succeed are those where a coarse-grained soil exists, in which the deeply descending roots could find sufficient moisture for their growth.

Professor Krasnov considers that although this view has a true

basis, it is too wide a conclusion, being founded merely on a study of the Nijni-Novgorod government, and that the watersheds of the country are very far from possessing the coarse-grained soil that Professor Kostitch expects. Also the woods do not themselves always follow the watersheds, but, on the contrary, are very frequently quite absent at such points.

Mr. Rodway, reviewing the American aspect of the case, introduces another agency. With him water becomes a most important agent in the distribution of trees, and he adduces examples of the results of inundations in this respect. Trees are not found in treeless regions, because water has never transported them thither, and they never were there, because no trace of their existence can be found.

The general result thus stated may be freely admitted, but at the same time it is very obvious, in Russia at any rate, that there is some special difficulty as regards tree-growth on the steppe. The precautions taken in cultivating trees in gardens and on the steppe is a case in point. The grass has to be carefully removed, and a little trench dug round the plant, to enable it to obtain the necessary water-supply. Whether it be that the grass itself absorbs the moisture, or that the soil is too fine for free percolation, is a question an answer to which it is not easy to obtain. Small trees have to be planted very thickly to prevent wind drying up the moisture.

Professor Dokoutchaieff has given expression to the following views: "The low-level districts of the Poltava government are devoid of woods, at the same time being rich in salts. The higher parts are, however, wooded, and the ground has but few salty constituents." In his opinion absence of tree-life and presence of salts are in close connection.

Streams, draining the upper parts of the government, carry down the salts in solution, depositing these in marshes or giving rise to salt-springs, when the lowlands are reached. As salt is a deadly enemy of tree-life, and as the lowlands being strongly alkalized do not admit of forest-growth, steppes are produced in such localities. Especially is this the case in the lowest parts, where the largest amount of salt is concentrated. These statements are practically the application of Lesquereux's views to the South Russian area.

As far as my own experience goes, I must agree with Professor Krasnov, that this theory appears untenable when applied to the South Russian Black Earth region as a whole, though it may be of great importance in its relation to individual districts, and especially to that area which lies immediately south of the distinct glacial boundary. Owing to the great extent of the Russian empire, and the broad regions over which its various deposits are spread out, there is a natural danger of the formation of separate schools of thought, each basing itself on the peculiarities existing in special districts, and raising local features to the rank of far-reaching generalities. Only after prolonged and friendly discussion will it be possible to establish those wider principles which must form the foundations for true progress in the subjects under discussion.

The facts on which such wider conceptions are based come out

forcibly when the conditions in Russia and N. America are compared. Both possessed an ice-sheet, or, at any rate, an abnormal glacier, occupying similar geographical positions. In both, the northern portions are rich in forest, lake, and marsh; whilst further south spread the broad prairie or the rolling steppe. Not only so, the similarity extends even to the consideration of soil and flora. Only the other day, a short account of North Dakota appeared in one of the newspapers, special stress being laid on the richness of the black soil which there exists. Parallelism of character has been accompanied by parallelism of theory, and turn by turn, climate, nomads, fine-grained silt, and presence of salts, have been used to account for the absence of tree-life.

Prof. Krasnov arrives at the conclusion that in Russia the process of dessication has gone further than in America; for, in the latter, as Lesquereux has shown, near the Gulf of Sandousk, on the Mississippi, may yet be seen the marshy prairie covered with small lakes. These views are founded on the supposition that the melting of the ice-sheet must have saturated the soil with water. Lesquereux, indeed, concluded that the prairie lands must have once been occupied by an unbroken chain of lakes and marshes; gradually the area has been drained, though traces are still left of the former predominance of more lacustrine conditions.

In Russia, the lakes still exist on a small scale in the Kharkov and Poltava governments; but these, it appears, are rapidly disappearing, having been far more numerous even within the memory of men still living. The shores of one visited by me at the village of Kvianovka, near Voroshba, were crowded with the shells of large *Limneæ* and *Paludinæ*, which had evidently been left behind on the lowering of the water-level. That the change has been of recent date is shown by the fact that the strip bordering this sheet of water is in a very marshy condition.

In these districts, too, corn often ripens without having received a drop of rain during the spring, whilst it is stated that the flora is rather that of the marsh than of the steppe. In the south, further removed from the original termination of the ice-sheet, the advent of showers at this season is one of the things most anxiously looked for by the agriculturist, and the flora is of a truer steppe character.

This interesting question of the floral distribution is also discussed by Professor Krasnov, who says: "The watersheds of the Donetz-Dnieper and Donetz-Don are very rich in species; along the Dnieper and Volga the number is at least 20 per cent. less. Without regard to climate, the rarest species are found on the highest ground of the district; these are partly steppe and partly Caucasian forms, characteristic of moist mountain meadow-lands near the terminations of glaciers. The districts of Constantinograd and Loubny, in the Poltava government, and those of Volchansk, Starobielsk, and Sviatoia Gora, in the Kharkov government, some of the highest districts in the south, are specially rich in these types. The steppe soil itself also changes its character according to the position, that on higher ground being the richer in humus."

In Russia, then, we have three distinct regions distributed in regular sequence from north to south, or more strictly lying in broad curves bending from N.E. to S.W., and running parallel to the line given by Murchison as the limit of distribution of glacial boulders.

To the north and west of this boundary division lies the great forest region, now much denuded by man; but still, especially in Lithuania, attaining magnificent proportions. Immediately to the south of this line lies the band, which shows a combination of forest, small lake, and patches of steppe. This latter passes directly but gradually into the true steppe region.

Prof. Krasnov, after a comparison of the American and Russian literature on this subject, concludes that the Black Earth region has gone through three distinct stages:—

1st. The stage of marsh formation, presumably the immediate result of the melting of the ice-sheet. During this period there would be a decided predominance of lakes and morasses, and a low-lying marshy flora would be conspicuous. Trees and steppe-grasses then only occupied the highest points.

2nd. The stage of drainage, connected with poverty of the subsoil waters. This stage has been passed through by the greater part of the steppes and prairies. In their northern portions there is still evidence of those water-holding depressions which on this hypothesis must formerly have existed, and even such traces are fast disappearing. These changes are accompanied by the immigration of a flora more suitable to a dry climate, and by the formation of Black Earth.

3rd. The wood stage, which is, as regards the south, as yet in its infancy. As the steppe is denuded, so the woods, or more commonly isolated trees in the first instance, advance along the valleys of the streams, and occupy the ravines. My former paper on Loess really dealt with the first, and part of the second above-mentioned stages. It is noteworthy that but little is said about this great deposit in the paper to which reference has been made above, although the general sequence of events suggested by me has been to a large extent borne out by Prof. Krasnov's results.

The zoological studies carried out by Professor Nehring have still further strengthened the position here being maintained. Since 1874 a series of papers have been written by him (see, for instance, Sitz. Ber. der Gesell. Naturforsch. Freunde, Berlin, 1888–89–90, p. 164) in which he has endeavoured to establish the existence of steppe-characters in Central Europe during Pleistocene time. Here again a triple division has been observed, each zone differing as regards the animal remains contained in it.

In the lowest, immediately succeeding true glacial deposits, occur the bones of animals, now living chiefly in tundra regions and higher latitudes, such as the Elk and Lemming. Besides these, the Reindeer, Arctic Fox, and Arctic Hare have been noticed. Not only so, but fresh-water mollusca are very abundant, species of *Limnea*, *Paludina*, and *Pisidium*, being especially noticeable.

In the second, or zone of Loess proper, a typical steppe fauna

commences to make its appearance, the Horse, Jerboa, and Marmot being especially characteristic. On the other hand the remains of Mammoth and Rhinoceros are found in close conjunction with these in Germany.

In Russia the smaller rodents persist at the present day, though these are now fast disappearing before advancing civilization. The steppe-rat still holds its own to a great extent, but when we consider that over forty thousand were destroyed in one year (and that in one district only, Stila, south of Ekaterinoslav governments), it will be readily understood that their extinction as such is but a question of time. In the Upper beds of the German Loess at Thiele, in Brunswick, the steppe rodents practically disappear, the Mammoth, Rhinoceros, Horse, Hyæna, and Lion alone carrying on the faunal history. The latter two animals never appear to have established themselves in the S. Russian area, but the first three are of typical occurrence. In the last zone forest-living animals commenced to appear, but it is to be feared have been unable to obtain a strong footing, thanks to the hunting propensities of mankind.

It is interesting to note that man seems at the present day to be engaged in a deadly struggle with what we should otherwise regard as a natural tendency, for whilst the forests, if left alone, would probably become successful invaders, they are ruthlessly cut down in the hour of victory.

In Germany, then, as in Russia, a steppe-region probably succeeded the period of lake and tundra, but the forests had long played an important part in the former ere the southward advance of the vegetation commenced in the latter country. Already in the time of Tacitus they were spread over the face of the country, forming a mighty fortress, behind whose defences Arminius could well defy the all-powerful Roman hosts.

In England the climatic conditions are so totally different that steppe-characters might well not have existed. Nevertheless, even here, as has been suggested by Mr. Clement Reid in "Natural Science," there is some evidence of the erstwhile presence of such plains over which the Saiga Antelope may have roamed at will.

The greater extension of the forests in former times is, of course, a matter of common knowledge; for we learn at the time of Cæsar's landing, Londinium was in the midst of the Middlesex forests, traces of which are still abundant, *e.g.* Epping Forest, Highgate and Hadley woods.

It therefore would appear that like conditions succeeded each other all over the North of Europe, but that our own island is ahead of both Eastern Germany and Southern Russia as regards historical development; probably due to its greater nearness to the edge of the continental plateau, and consequent more rapid transition to an insular climate.

Before summarising the views set forth in the present paper, it may be of interest to call attention to the humus-bearing Loess which lies at the base of the main deposit. Prof. Armachevsky

(Geological Outlines of the Tchernigov Government, p. 129) remarks: "Of special interest is undoubtedly the Loess, which contains a marked percentage of humus, and which may be described as *humus-bearing Loess*. This structure is always met with in the *lower* horizons of the Loess, and may sometimes attain a thickness of seven feet. It is distinguished from ordinary Loess by its grey-brown, chestnut-brown, or dirty grey colour, and is at the same time more compact and clayey; otherwise its characters are those of the true Loess. Two analyses gave 2·04 and 3·03 per cent. of humus respectively."

This interesting condition is one to which attention should very specially be directed, seeing that it alone can furnish evidence as to the actual condition of the open country lying to the south of the glacier. There is not at present sufficient evidence to show that steppe lands, as such, were then already marked geographical features; and there are some conditions, such as the existence of isolated tree-islands in the midst of the plains, which rather tend to prove the greater extension of woods at that time, and their partial destruction by the flooded Loess-bearing waters. With this brief statement I must leave this complex subject.

In this paper I have endeavoured to show, first, that the three main propositions submitted by me in my previous note on the Loess are fully confirmed, not merely by the change in character of the strata in a vertical direction, but also by the variations they display when traced horizontally from north to south.

Not only do we find a gradual transition from beds containing fresh-water shells to those which bear only evidence of a steppe fauna and flora, but we have similarly the existence of marshes and lakes (though disappearing) in the north of Little Russia; whilst in the southern parts broad steppe and grassy plains alone prevail.

These views are further strengthened by a consideration of the faunal changes which have taken place in South Russia. Here the Mammoth and Rhinoceros seem more abundant in the lower beds, and appear to be more rapidly replaced by the smaller steppe forms than is the case in Germany. Perhaps it may be that in the latter country less continental conditions may have prevailed, and possibly it may never have attained to the perfection of steppe conditions developed further east.

As regards the flora, there remain here and there some traces of the older vegetation, but in general the glacial and Caucasian types have practically disappeared, marshy forms now predominating in the northern, and steppe-forms in the southern governments of Little Russia.

The suggestion, then, is, that the position of the Loess has been originally determined by the manner and conditions of its origin, but from the time that the glacial melting ceased to have effect it was subject to the action of denuding influence, the wind becoming a principal factor when the main outlines of steppe-life were established.

Secondly, the Black Earth is merely a special closing feature in

the sequence of a long history, a last page in a many-chaptered volume. Its position and character are, in the main, determined by that of the Loess, and it is merely that deposit rich in humus, resulting from the decomposition, through long ages, of many generations of grasses and steppe plants. Not only has it not resulted from changes of a complex, sudden, and variable character, but it is actually being produced at the present day, a layer several inches thick covering some of the ancient Tartar tumuli so frequent on the Russian steppe.

Further, there is no proof of the former existence of trees on these areas; in fact there is actual evidence forthcoming against such a view, both in the pages of history and in the facts of agricultural development. The winds that sweep the steppes, and carry far and wide the loose powdery soil, are directly opposed to the growth of wood or forest on these plains. The Russo-German colonist finds it necessary, when attempting to start a plantation, to grow the trees close together, so that the outer ring may protect the inner ones from the blast.

Circumstances have been mentioned which tend to show the necessity of overcoming special obstacles ere tree-life can be established, and also proving that it is only invading the steppe-lands along lines where denudation influences are active. The variations in richness of humus may be largely due to climate, and the alteration in thickness to the action of the wind; but in any case the Black Earth would appear to be a typical surface formation, resulting from the direct chemical combination of organic materials with the soil constituents.

IV.—Jurassic Ammonites: On the Genus *Cymbites* (Neumayr).[1]

By S. S. Buckman, F.G.S.

THIS paper deals with the species which are considered to belong to the genus *Cymbites*, and the reason for placing *Paroniceras*, Bonarelli, as a synonym. A few notes are added concerning *Agassiceras*, which is also affected; and a description of the little-known species *Agassiceras Colesi* (J. Buckm.) is given.

Genus, Cymbites, Neumayr, 1878.

(Type, Cymbites globosus, Zieten, sp.)

1875. *Agassiceras*, Hyatt, New Genera Amm.; Proc. Boston N. H. Soc. vol. 17, p. 225 (*pars*).
1878. *Cymbites*, Neumayr, Unverm. auftret. Ceph.; k.k. geol. Reichsanstalt. Bd. 28, Heft 1, p. 64 [28], footnote.
1884. *Agassiceras*, Zittel, Palæont. Bd. i. Abth. 2, Lief. iii. p. 455.
1884. *Cymbites*, Zittel, *op. cit.* p. 456.
1887. *Agassiceras*, Haug, Polymorphidæ; Neues Jahrbuch für Mineralogie, etc. Bd. ii. p. 94 (*pars*).
1889. *Agassiceras*, Hyatt, Genesis Arietidæ; Smithsonian Contrib. Knowledge, 673, p. 194 (*pars*).
1893. *Paroniceras*, Bonarelli, Sul Toarciano, etc.; Boll. d. Soc. geol. italiana, vol. xii. fasc. 2, p. 202 (10).

Also *Phylloceras*, Blake, and Wright, *pars*. *Harpoceras*, *pars*, Meneghini et auct. *Pœcilomorphus*, Bonarelli, *Pelecoceras*, Haug, etc.

[1] See the author's previous paper, Geol. Mag. July, No. 361, p. 298.

Cymbites globosus (Zieten).

1830. *Ammonites globosus*, Zieten, Verst. Würt. pl. 28, fig. 2.
1849. *Ammonites globosus*, Quenstedt, Ceph. pl. 15, fig. 8.
1853. *Ammonites globosus*, Oppel, Mittl. Lias Schwäbens. pl. 3, fig. 7.
1864. *Ammonites lævigatus*, Dumortier (*non* Sowerby), Bass. Rhône, pl. 18, figs. 5 and 6.
1885. *Ammonites globosus*, Quenstedt, Schwäbischen Ammon. (pl. 22, figs. 45, 46?),[1] pl. 42, fig. 29 only.
1889. *Agassiceras lævigatum*, Hyatt, Genesis Arietidæ; Smithsonian Contrib. Knowledge, 673, pl. vii. fig. 13 only.

(But not *Cymbites globosus*, Geyer, Ceph. Hierlatz; k.k. geol. Reichsanstalt, Bd. xii. No. 4, pl. iii. fig. 26, 1886.)

An involute, smooth, globose shell, always very small. There is a tendency to enlarge the umbilicus in the last whorl, and to produce an evolute shell. The septa are exceedingly simple for an Ammonite, one two-pointed lobe on the periphery, and two simple lobes on the side.

There is but little difference apparently between the forms figured from the *angulatus*-zone (Dumortier) and those from the *margaritatus*-zone (Quenstedt). Some of the figures quoted in the above synonymy are rather more widely centred than others; and this, together with the length of time above-noticed, makes it doubtful if they are all the same species. As, however, the figures are small it is not safe to pass a definite opinion on the subject one way or the other. Enlarged figures of the forms from each horizon, all to the same scale, are required. Further, it is necessary that the inner whorls of species on the same horizons which might be mistaken for them should be similarly figured.

This species is quoted from the *angulatus-*, *Bucklandi-*,[2] *obtusus-*,[2] *oxynotus-*, and *margaritatus*-zones. I can call to mind no other Ammonite with anything like this range.

Cymbites lævigatus (Sowerby).

1829. *Ammonites lævigatus*, Sowerby (*non* Reinecke), M. Conch. pl. 570, fig. 3.
1849. *Ammonites Davidsoni*, d'Orbigny, Prodrome i. p. 225, No. 38.
1856. *Ammonites lævigatus*, Oppel, Juraf. p. 81.
1875. *Agassiceras lævigatum*, Hyatt. Two new genera Ammonites; Proc. Boston Nat. Hist. Soc. vol. 17, p. 226.
1887. *Agassiceras lævigatum*, Haug, Polymorphidæ; N. Jahrbuch für Mineral, etc. Bd. ii. p. 94.
1889. *Agassiceras lævigatum*, Hyatt, Genesis Arietidæ; Smithsonian Contrib. Knowledge, 673, pl. viii. fig. 12 (9, 11?).

This species is thinner and more evolute than *C. globosus*; and it may be regarded as a development of that form having characteristics which are due to the earlier inheritance of the adult features of that one. Hyatt's figure 12 is typical; but his figs. 9, 11, are developments of this species to the subcostate stage. They are possibly connecting links; thus his fig. 9 might lead to *Agassiceras*, and his fig. 11 to something like *planicosta*.

[1] Probably young forms of *oxynotus*.
[2] These records may refer to *Cymbites lævigatus* (Sow.).

Sowerby was not the first to use the name *lævigatus* for an Ammonite; and, therefore, d'Orbigny placed the name *Davidsoni* instead of *lævigatus*. Oppel, however, says: "As Reinecke's *lævigatus* is a poorly-described, ill-defined species, and Lamarck's *lævigatus* is a synonym of *A. Lewesiensis*, I make use of Sowerby's name" (Juraf. p. 82). It is wise to follow this example, because there may reasonably be some doubt whether d'Orbigny meant by *Davidsoni*, which he placed in the Middle Lias, the same species as Sowerby's *lævigatus*, which is a well-known Lower Lias form. Further, Dumortier has applied d'Orbigny's name *Davidsoni* to a species which is not Sowerby's *lævigatus*.

Cymbites lævigatus is a well-known fossil at Lyme Regis; but curiously it found no place in Wright's Monograph. Oppel gives the horizon as just over *Am. Bucklandi* at Lyme Regis. Hyatt says that it occurs there with *obtusus*.

Cymbites Berardi (Dumortier).

1867. *Ammonites Berardi*, Dumortier, Bassin Rhône ii. pl. 21, figs. 5–7.

If this be not the young form of a larger Ammonite, then it must be regarded as an evolute development of *C. globosus*, which has acquired slight costæ, but has not lost its thickness. It looks not unlike a much larger edition of the inner whorls of *planicosta*; and it may be a species connecting *globosus* with *planicosta*.

From what Dumortier says, it occurs in the *Turneri*-zone.

Cymbites obesus (Reynès).

1879. *Ammonites obesus*, Reynès, Monog. Amm. pl. xxvi. figs. 10 and 11.
1887. *Agassiceras obesum*, Haug, Polymorph.; N. Jahrbuch für Mineral, Bd. ii. p. 96.

This form is the further development—more evolute and showing a faint keel—of a form like the striate *globosus* (Hyatt's *lævigatus*, pl. viii. fig. 13); and it leads to the next species.

Bucklandi-zone (Reynès).

Cymbites Davidsoni (Dumortier).

1867. *Ammonites Davidsoni*, Dumortier, Bassin Rhône ii. pl. 21, figs. 1 and 4.
1887. *Agassiceras Davidsoni*, Haug, Polymorphidæ; N. Jahrbuch für Mineral, etc., Bd. ii. p. 96.

This is a subcarinate form which seems to be merely a compressed development of *obesus* occurring on a higher horizon. The compression causes a difference in the whorl-shape—in *obesum* the whorl is depressed, in this species it is compressed.

Turneri-zone (Dumortier, interpreted).

Cymbites, sp.

1885. *Ammonites*, cf. *globosus*, Quenstedt, Amm. Schwäb. Jura, pl. 42, fig. 39 only.

A somewhat evolute, densisept form which shows a small subcarina. The subcarina, which is a nascent feature in this series, is of interest in connection with *Cymbites sternalis* (see later).

Lias *ε*, Quenstedt. (*Margaritatus*- or *spinatus*-zones.)

Cymbites sternalis (von Buch).

1843. *Ammonites sternalis*, d'Orbigny, Ceph. Jurass. Pal. franç. pl. 111.
1885. *Ammonites sternalis*, Quenstedt, Amm. Schwäbischen Jura, pl. 50, figs. 6 and 7.
1893. *Paroniceras sternale*, Bonarelli, sul Toarciano, etc., p. 202 (10).

Von Buch's work is not at present accessible, so that my remarks must be considered to refer to the above-quoted figures. D'Orbigny's figures appear to indicate that the carina was phyletically nascent in this species—a carinate periphery being, in this case, a developmental advance upon one uncarinate.

Upper Lias. Zone ?

Cymbites subcarinatus (Young and Bird).

1822. *Nautilus subcarinatus*, Young and Bird, Geology of Yorkshire Coast, pl. xii. fig. 7. Also 1828, ed. 2, pl. xii. fig. 9.
1829. *Ammonites subcarinatus*, Phillips, Geology of Yorkshire, pl. xiii. fig. 3. (The figure is really not identifiable.)
1862. *Ammonites subcarinatus*, Oppel, Pal. Mitth. pl. 44, figs. 1 and 2.
1876. *Phylloceras subcarinatum*, Blake, Yorkshire Lias, p. 297.
1884. *Phylloceras subcarinatum*, Wright, Lias Ammonites Pal. Soc. pl. 81, figs. 1–3.
1893. *Pœcilomorphus subcarinatus*, Bonarelli, Osserv. sul Toarciano; Boll. Soc. geol. italiana, vol. xii. fasc. 2, p. 5.

The subcarinate periphery of *sternalis* has developed into the bisulcate-carinate periphery of *subcarinatus*; the striæ have become ribs, and the small umbilicus has become larger; these are all progressive developmental features seen in analogous series.

This species appears to be well distributed, but not common. It occurs in Yorkshire, in the Midlands, and in the South of England. At Shepton Beauchamp, in Somerset, I found it *in situ*, just at the top of the beds, with *Harpoceras falciferum*—in fact just at the place where *Harpoceras falciferum* and *Hildoceras bifrons* came into contact.

The position of the two species, *sternalis* and *subcarinatus*, has always seemed to be a puzzle to palæontologists,[1] yet their relationship to the *globosus* series appears obvious from their septation and general characters. They differ only in their peripheral aspects; but this is merely a matter of development. When an Ammonite-periphery departs from the arched shape, it becomes either elevated or depressed medianly. In the former case its full phases of development are, in consecutive order, fastigate,[2] subcarinate, carinate, carinate-bisulcate. These changes can only become of generic value when the phyletic series splits into two stocks—one of which retains, say, the arched periphery, the other acquires a carinate periphery.

Now *Cymbites* is, in my opinion, the radical of all *Ammonaceæ*; and, unlike Hyatt, who goes to *planorbis* for his radical, I consider that *globosus*-like Triassic species—perchance *Nannites*—are the parents of our Lower-Lias Ammonites. From *Cymbites* the various Ammonite-stocks have been cast off at different times. Thus

[1] "Forms very doubtful as to their position."—Neumayr, Unverm. Ceph. p. 67.
[2] *Fastigatus*, rising evenly, like the roof of a house; sloping.

Arnioceras is an example of a derivative from *Cymbites*, acquiring a carina while *Cymbites* itself remained uncarinate: here the carina becomes of generic importance. But in the cases of *sternalis* and *subcarinatus* there does not seem to be any breaking up of the stock—simply developmental change in *Cymbites* as a whole. In this case a generic name for *sternalis* otherwise than that of *Cymbites* does not appear to be needed; and Bonarelli's *Paroniceras* seems not to be required. That author places *subcarinatus* again in another genus—*Pœcilomorphus*; but this is unnecessary for the same reason. Further, the type species of *Pœcilomorphus* is the *Am. cycloides*, d'Orbigny, which possesses sigmoidal costæ, whereas those of *subcarinatus* are nearly direct.

Blake and Wright placed *subcarinatus* as a *Phylloceras*, but this was a decidedly unfortunate position, which the septa at once negative. No wonder that Bonarelli in quoting this adds ! after it.

As to the position in a family arrangement, the inclusion of *Cymbites* in the *Arietidæ* appears most convenient. The lower forms are decidedly goniatitic in appearance, and the suture-line throughout is of an Arietan character; further, *Cymbites* is the radical stock of several series of *Arietidæ*, though it seems also to be the radical of the *Polymorphidæ*,[1] *Deroceratidæ*,[2] etc. Biologically considered, however, the *Arietidæ* are the lowest of the *Ammonaceæ*.

Hyatt did not include *sternalis* and *subcarinatus* in his magnificent Monograph on the *Arietidæ*;[3] but he placed *lævigatus* in his genus *Agassiceras*; in fact, *Agassiceras* has priority of *Cymbites*. If it were to be insisted that *Agassiceras* should be the generic name for the *globosus*-group, then *Cymbites* would be lost, and a new name would have to be found for *Scipionianus* and allied forms. A reasonable way out of the difficulty seems to be the present use of *Cymbites*, and the employment of *Agassiceras* as a generic name with *Scipionianus* as the type-species. To that genus[4] would belong *Gaudryi* (Reynès) *Sauzeanus* (d'Orbigny)—removed from *Coroniceras*, where it was placed by Hyatt—and *Colesi* (J. Buckman), a species which has been altogether overlooked. The only difficulty in the matter is the possibility of *Oxynotoceras oxynotum* being derived directly from *Agassiceras*, in which case the name *Agassiceras* would be rightly employed for the *globosus*-series, and *Oxynotoceras* for the *Scipionianus*-series, and *Cymbites* would have to go.

The present is a suitable opportunity to give a description of *Agassiceras Colesi*.

[1] Through *Polymorphites polymorphus* (Quenstedt).

[2] Through *Mieroceras planicostatum* (Sowerby). The *Stephanoceratidæ* are descended from the *Deroceratidæ*. The *Amaltheidæ* and *Oppelidæ* are not traceable to any of the *Cymbites*-forms directly, but they give ontogenetic evidence of a somewhat similar phase in phyletic development.

[3] Smithson. Contrib. Knowledge, 673.

[4] To that series *latum* ("*Coroniceras latum*," Hyatt) should probably be added as the form connecting *Agassiceras* with *Coroniceras*. The readiest generic distinction between *Coroniceras* and *Agassiceras* will be found in the greater degeneration of the septa in the latter, *Coroniceras* proper being distinguished by long lobes.

AGASSICERAS COLESI (J. Buckman).

1845. *Ammonites Colesi*, J. Buckman, Murchison's Geology of Cheltenham, second edition, p. 89, pl. 12, fig. 2.

Discoidal, much compressed, strongly carinate. Whorls in youth evidently gibbous, rather strongly and widely costate, gradually becoming flatter-sided, and ornamented with direct, slightly inclining costæ, which have a strong forward projection on the periphery, where they are very obscure. The costæ, which are slightly swollen at the edge of the inner margin, and again a little more swollen at the bend on the outer area, become practically obsolete towards the end of the whorl (specimen 89 mm. diameter). Periphery fastigate divided by a strong carina. Inner margin well-defined on last whorl, upright. Inclusion one-third.

This species is a dwarf development of the evolute form of *Scipionianum*.[1] It does not seem to show the unispinous stage of that species but exhibits only a costate stage, and even further decline at any early age, namely, obsolescence of the costæ. In fact degeneration of ornament is noticeable, while the form is small as compared to *Scipionianum*.

The absence of tubercles and the small size it has attained when the ribs become almost obsolete distinguish this form from *Scipionianum*. The original type-specimen, which was badly figured, of reduced size, in my father's work, is now in my cabinet. It came from the Lias of a railway cutting at Swindon, near Cheltenham, and seems to be a rare form. Unfortunately exposures of Lias in the neighbourhood, or in fact in the Vale of Gloucester, are few and far between now.

P.S.—Since the above went to press I have received a pamphlet, "Ueber Ammonoideen mit anormaler Wohnkammer," by Dr. J. F. Pompeckj (Vereins f. Vaterl. Naterkunde in Württ. 1894). This may be consulted in reference to *Cymbites*, pp. 238–240; and it reminds me that I have overlooked

CYMBITES CENTRIGLOBUS (Oppel).

Pal. Mith. p. 140, 1862, the type of which is, no doubt, the third reference given under *C. globosus* (above). From that place may be removed, to be added here, the second reference, and probably

[1] Included by authors under the name *Scipionianus*, evolute and involute forms may be distinguished—the former in Reynès and Wright's figures, the latter in d'Orbigny's. Certainly Reynès calls his "*Ammonites Scipionis*," but this is only short for *Scipionianus*, d'Orbigny, whose authority he gives. Hyatt, however, distinguishes *Agassiceras Scipionianum* and *Ag. Scipionis* as two species. His "*Ag. Scipionis*" seems to be divisible into three: 1st, *Scipionis* (Reynès), which he quotes—an evolute form of *Scipionianus*, as alluded to above; 2nd, *Scipionianus olifex* (Quenstedt, Amm. Schwäb. Jura, pl. 17, figs. 7–10), which he also gives in his synonomy—this seems to be a costate retrogression of *Scipionianum*, and therefore a cousin of *Colesi*, from which it differs in being more involute, more closely costate to a larger size, and it probably deserves distinction as *Agassiceras olifex*; 3rd, a form of which an outline sketch is given in pl. 13, fig. 8 (Genesis *Arietiæ*)—a much more involute fossil than *olifex*, apparently very retrogressive, deserving a distinct name.

the fifth, and also Quenstedt, Jura, pl. 21, fig. 8. This is the *Margaritatus*-zone form. Oppel considers that Zicters's species is the *Obtusus*-zone form. The difference between them seems to be chiefly one of coiling, difficult to appreciate except in the handling of specimens.

At page 289 Pompeckj states in reference to *Cymbites* and an opinion of mine that Ammonites with "normal" body-chambers ("concentrically umbilicate") cannot be the descendants of those with abnormal body-chambers ("excentrically umbilicate," S. S. B.). In making this assertion he has overlooked *Dactylioceras* and *Stephanoceras*, both examples of the earlier inheritance of "excentric umbilication"—the result of ancestral "abnormal" body-chambers—producing "concentric umbilication." After all, the so-called abnormality is a very normal feature of phyletic development; and the incorrectness of Pompeckj's statement I hope to prove at another opportunity.

V.—Twenty Years' Work at the Younger Red Rocks.[1]

By the Rev. A. Irving, D.Sc., B.A., F.G.S.

HAVING made my first acquaintance with that puzzling series of strata which bridges over the vast interval of geologic time between the Carboniferous and the Jurassic in the Nottingham district during a residence of eight years in the good old town (see Proc. Geol. Assoc. vol. iv.; also Quart. Journ. Geol. Soc., November, 1875), the meeting at Nottingham seems a fitting occasion for summarizing the results of further work in connection with those rocks, as opportunities have offered, during the last twenty years. Those investigations have extended to other parts of the Midlands, the Severn country, to Central Germany, the Eastern Alps, and to Devonshire.

As Reporter to the Sub-Committee of the *International Geological Congress* for the "Permian and Trias," I had unusual facilities for correlating the results of my own work in the field with those of other workers. For this reference may be made to the Report issued by the Congress.

In a paper on the "Classification of the European Rocks known as Permian and Trias" (Geol. Mag. Dec. II. Vol. IX. 1882), I discussed more at length the results obtained down to that date, with the aid of the German literature of the subject, my own observations in the German and English areas, and the assistance of Prof. Jules Marcou. These results may be briefly stated as tending to establish for the European area generally the definite existence of two independent systems, the one (the Permian or Dyas) marking the close of the Palæozoic history of the European area, with which it is connected by its fauna and flora; the other (the Trias) forming the base of the Secondary series of rock-formations. I was, therefore, compelled to abandon the view as to the continuity of the

[1] A paper read at the Nottingham Meeting of the British Association in 1893 (Section C).

whole series implied in the name "poikilitic," which I had (from a too limited sphere of observation) previously adopted for the North Midlands, as Prof. Phillips had done for the Severn country in his work on the Geology of Oxford, etc. Observations made in the Alps and information obtained from the writings of Gümbel and other Continental geologists, were communicated to this section at the Southampton meeting in 1882, and published in fuller form the same year (GEOL. MAG. November, 1882). In that paper it is shown that the Alpine Trias admits of direct correlation with the Trias of Germany by means of fossil-contents (the horizons of the Muschelkalk being very definitely determined by many characteristic fossils common to both areas), while the Permian or Dyas (the Trias in part of von Hauer) is closely tied on to the true Trias by the transition series of Gümbel (plant-remains in the sandstones at Neumarkt near Bozen, fauna of the Bellerophon Limestone). The importance *of further investigation of the true stratigraphical relation of the Dyas and Trias of Germany*, and (as involved in this question) *the true position of the Bunterschiefer of Murchison, were thus brought into prominence.* This investigation (with the assistance of Prof. Geinitz, Prof. Ritter von Hauer, Prof. Liebe, and other German geologists) I was able to make in the summer of 1883. The results were given to the world in two papers, one "On the Dyas and Trias of Central Europe, and the true Divisional-line of those two Systems" (Quart. Journ. Geol. Soc. August, 1884); the other on "The Permian-Trias Question" (GEOL. MAG. July, 1884). Those two papers were received with expressions of the highest appreciation by so great an authority as Prof. Marcou, and my results were confirmed by the work of Geinitz and Dittmarsch in the following year (*Nova Acta Acad. Leopoldinæ*, 1885)—"On the limits of the Zechstein Formation and of the Dyas in General," by H. B. Geinitz. The contention that the so-called Bunterschiefer was an uppermost member of the Trias, was thus refuted all along the line; and a stratigraphical break between the Dyas and Trias in the German area was thus established on physical as well as on palæontological evidence sufficiently strong to carry conviction to the mind of Prof. Hull, who had previously given his adherence to the view implied in the Permian Trias of Murchison.

The chief results down to 1884 would thus appear to be:—

1. The more complete establishment of the Permian or Dyas as an integral and independent system, though subordinated on palæontological grounds to the Carboniferous, to which it is in some localities (*e.g.* in the Warwickshire area) conformable, though more often unconformable, as in Notts, in the North-Eastern area (where the Rothliegendes is almost, if not entirely, absent), in Thüringen, in Saxony (Zwickau and other places in the basin of the Erzgebirge). This differentiation has been further confirmed by the later work of Mr. De Rance in the Midlands, even for the Warwickshire area.

2. The existence of a great difference in the relation of the Permian and Trias to the adjacent palæozoic and archæan land, the coarser detritus of the Permian breccias (both in the German and

English areas) being traceable to the older rocks of the region as their source, in the valleys and creeks and fjords of which it was deposited; while the materials of the coarser sediments of the Trias (Bunter) are of a more varied nature, including, and in some localities almost entirely made up of, well-rolled detritus (often containing fossils of Silurian age) derived from a wider area, and in some cases transported from a considerable distance. The striking contrast between the German Dyas and Trias, based on physical facts alone, taken along with the stratigraphical hiatus which exists between them, and the complete concordancy of the whole succession of the strata which constitute the German Trias, harmonizes fully with the palæontological evidence which has been worked out so thoroughly by Geinitz and others on the Continent, and by King in this country.

The Devon Area.

With the results indicated above pretty well established and the knowledge gained at first-hand of the German Rothliegendes and its English representatives, it is not surprising that on my first examination of the Red Rocks of the Devon Coast Section in 1887 I was unable to accept the mapping of them as wholly of Triassic age, or the interpretation of that magnificent coast section from Seaton to Torquay, which had been published by Mr. Ussher in the Quart. Journ. Geol. Soc. The attempt on my part to carve out a Permian system in the paper published in the Quart. Journ. Geol. Soc. in 1888 was officially ignored; but when, after some delay (mainly on official grounds), Prof. Edward Hull was able to verify my main contention from field-observations, a very energetic attempt was made to explain it all away (see discussion of the Papers by Prof. E. Hull and A. Irving in Quart. Journ. Geol. Soc. for 1892). Further work in the field in the year 1892 (see Quart. Journ. Geol. Soc. for February, 1893) led to the definition of the base of the Keuper along the Otter Valley, as it had been previously recognised in the Valley of the Sid. The surrender by Prof. Hull of the only point of importance on which we had differed,[1] on going over the ground together the year before, cleared the issues of the controversy, and made a complete and direct correlation of the Devon Red Rock Series (from stratigraphical and lithological evidence) with those of the Midland and Severn country, and with those of Central Germany, not only possible but easy.

In my 1892 paper I dwelt upon the importance of the evidence furnished by the contemporaneous volcanic rocks in the breccia-sandstone series of Devon (just as they occur in the Permians of the Solway Basin and of Central Germany), and on the other hand the entire absence of them from the undoubted Trias of Devon (as they are absent from the Trias of the two regions just mentioned). The value of this comparative evidence was generally admitted in the discussion of that paper at the Geological Society. I felt, however,

[1] That is to say, the age of the great red marl series below the Budleigh Salterton Pebble-bed. (See Q.J.G.S. vol. xlix. p. 83.)

that clear and unmistakable proof of the *contemporaneity* of the intrusive rocks with the breccias was wanting; and it remained, therefore, a somewhat moot point whether the breccias were not on the whole younger than the volcanic outbursts of the district, the fragments of which are abundant in the breccias. Since this meeting began, however, Mr. Ussher has kindly informed me of observations made by himself of the volcanic rocks overlying portions of the breccia-series, which we may, therefore, without much hesitation, correlate with the pre-porphyritic stage of the Rothliegendes of Central Germany. We may thence conclude that the very oldest Permian rocks of Europe are represented in the Devon region.

Prof. Hull has in his paper of 1892 (see Quart. Journ. Geol Soc. vol. xlviii.) dwelt upon the great unconformity of the breccias with the Devonian Limestone, as seen in the cliffs above Babbacombe Bay, where the detrital materials appear to fill an ancient (pre-Permian) fjord or valley of the older Devonian land: to this I should like to add an instance of unconformity, exhibited in a very fine section at Saltern Cove, near Paignton, where the breccias with intervening bands of coarse sandstone are seen resting nearly horizontally upon the planed-off edges of the stratified slates and grits of Lower Devonian age. We have, therefore, in the neighbourhood of Torquay clear evidence of even a greater break in the stratigraphical sequence between the lowest portion of the Permian and the older rocks than that which exists at Zwickau and other places in that part of Saxony between the unconformable Coal-measures and Naumann's "pre-porphyritic stage" of the Rothliegendes; or that which exists (as seen in the Kimberley section) between the unconformable Upper Permians (Magnesian Limestone and Marl Slate) and the highly inclined Coal-measures.

Subjoined are two section-diagrams illustrating this unconformity in the Devon and Notts areas:—

The frank recognition of the presence of a system of rocks of Permian age in Devonshire by Sir A. Geikie in his Presidential Address to the Geological Society of London in 1892, and the re-mapping of the Devon Red Rocks (nearly according to the boundary-lines indicated in my two later papers) on the new edition of the one-inch Map of the Geological Survey, which is exhibited at this meeting of the British Association, is a result, not only gratifying to myself, but one on which I think we may congratulate the Director-General and his colleagues. The older mapping of the Devon area by De la Beche is now officially superseded by the introduction of the Devon Permians (*cf.* the writer's remarks, in Q.J.G.S. vol. xlix. p. 83).

Physical History of the Series.

I have written so much in my various papers on the physical relations of these rocks to one another, and to the older formations, that it would be out of place on the present occasion to do much more than refer to those papers.

The land-shore- and bay-origin of the great detrital Permian

deposits (the breccia-sandstone series), claimed by the German writers for their area, is found to be equally true for the West Midlands and for Devonshire; but my work has led me (as my papers show) to recognise *terrestrial* deposits in them to a greater extent than our German confrères have done.

To a geologist familiar with the Permian of Notts, there is little difficulty in recognising the great red-marl series of Devon west of the Aylesbeare line of hills, as replacing homotaxially the marine Magnesian Limestone of the northern area; since in Notts the two

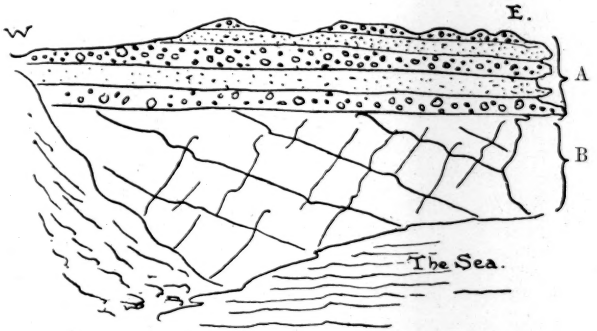

Fig. 1.—Coast-section at Saltern Cove (Tor Bay), Devon, showing unconformity of Permian breccia-sandstones with the Lower Devonian.

A Breccias and thin beds of irony sandstone.
B Lower Devonian slates with bands of quartzite, intersected by quartz veins.

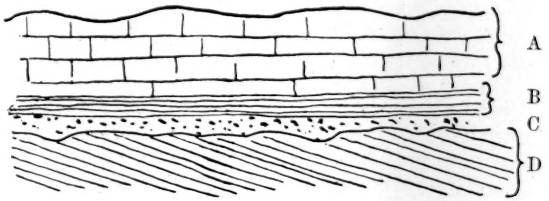

Fig. 2.—Railway section at Kimberley, Notts, showing unconformity of Upper Permian (Magnesian Limestone and Marl Slate) with the Coal-measures.

A Magnesian Limestone. B Marl Slate. C Breccia. D Coal-measures.

are bound together by the closest of all ties—interstratification. And the marls of the two areas are identical in character. That they are the finer washings-out from the coarser detritus, and the sediments thrown down along with the chemically-precipitated peroxide of iron (to which they owe their prevalent colour) in shallow enclosed basins, is to me the most probable theory as to their origin; and there would appear to be no serious objection to the view which regards them as the "Continental" equivalents of marine Magnesian Limestone of the North of England and the marine Zechstein of Germany, with both of which such marls are intimately associated.

As to the coarser detrital material of the Bunter, which clearly gives us a record of conditions very different from the lacustrine conditions under which the Keuper marls were deposited, I have never been able to see how a riverine origin for these coarse and irregular deposits can be reconciled either with their structure, their composition, or their geographical distribution. There are plenty of sections in and around Nottingham (Castle Rock, Church Cemetery, Sneinton, and other places) where these structural characters may be studied. More recent work has but confirmed the view I put forward twenty years ago as to the rocks of the Pebbly Sandstone type (such as we have in Notts) consisting of Triassic *sandbanks* deposited in narrow *tidal* seas; and more extended observation of the great pebble-beds of the Warwickshire and the Budleigh Salterton type, compels me to regard them as the "chesil-banks," which formed the shore-equivalents of the sandbanks.

VI.—On some Life Zones in the Lower Palæozoic Rocks of the British Areas, as defined mainly by Researches during the Past 30 Years.

By Henry Hicks, M.D., F.R.S., F.G.S.

IT not unfrequently happens in these days of superabundant scientific periodical literature that articles appear in which the authors, usually unwittingly, and generally from want of leisure, fail to give an adequate idea of the work of authors anterior to periods with which the writers are more specially acquainted. The injustice thus perpetrated can best be prevented by giving occasionally a brief resumé of work done in certain formations and in special areas during a given period. The present time seems to me appropriate for giving such a resumé in the Geological Magazine. The first Number of the Geological Magazine was published exactly 30 years ago (July, 1864), and in articles in the first Number by two eminent palæontologists (Prof. R. Jones, the then Editor, and Mr. J. W. Salter) we have clear and definite statements relating to the advances which had been made, and to the prevailing influences affecting geological thought at that time. The writings of Edward Forbes, Darwin, and Huxley were then producing a marked effect, and workers were led to search more carefully than had ever been done before for causes which may have tended to influence the distribution of life in the past, and many of the methods of research now in use are the outcome of the advances then made. It was undoubtedly a period marked by great changes in *methods* of research, but, fortunately, facts which had been well established and the means by which they had been obtained were not forgotten. The general effect was well described by Prof. Rupert Jones in the following passage in the Editorial Article, Vol. I. p. 3, entitled "The Past and Present Aspects of Geology": "It is now rightly considered legitimate to call in the agency of forces which, though not seen in operation in nature, may be evoked in the laboratory; and we thus seem to be in a fair way

of obtaining an insight into the causes of some of the most obscure physical phenomena. These attempts to enlarge the legitimate field of geological investigation may, therefore, be considered to have been attended with results beneficial to Science; and instead of the single line of research of a century ago, we have now a perfect labyrinth, each path being an avenue of thought paved with its fundamental ideas and supported and lined by the facts that have been accumulated by Geologists during the last fifty years.

"The present epoch in the history of Geology may also be said to be characterized to some extent by scepticism as to the exact truth of at least one of the fundamental principles to which we have alluded, namely, the contemporaneity of strata which contain the same or similar fossils, and which are geographically far apart. The late Professor Edward Forbes was the first to cast doubt on the general belief, and his opinions have been recently reiterated in a more or less modified form by several other geologists. Moreover, there is a general tone of wholesome scepticism respecting other matters, noticeable in recent geological works; especially as regards the simplicity of several phenomena, which are thus apparently being shown to be much more complex than has been supposed, whilst some few others are being proved to be more simple."

In the same Number, page 5, Mr. Salter, who two years previously had discovered *Paradoxides Davidis* at St. David's, and to whom in the meantime I had submitted material enough to enable him to announce at the meeting of the British Association of that year that the work had "already brought to light more than thirty (new) species of fossils, most of them Trilobites" (Geol. Mag. Vol. I. p. 289), and who was then about describing the fossils obtained by Mr. W. Vicary of Exeter from the Budleigh Salterton Pebble Beds, in his article "On some Points in Ancient Physical Geography, illustrated by Fossils from a Pebble-bed at Budleigh Salterton, Devonshire," said: "A sea-side walk, with a hammer in the pocket, may discover a new world by accident; for, as Darwin, Lyell, and Ramsay have told us, the unrepresented past times have been *far greater* than those of which we have a geological record, and fragments of the missing pages may turn up at any time. It is hard to realize this, no doubt . . . . . yet every now and then we alight upon new geological kingdoms; and still oftener on new provinces of old and well-established ones. An obscure, but novel, group of organic remains comes to light in some well-worked district, for which we have as yet no fixed geological place. Then the bed containing it is found to have a more extended range; it begins to be recognised by a local name; and, after undergoing the usual ordeal of doubt and disbelief attached to a new-comer, and being variously assigned as a local variation of some better-known *stratum*, it settles at length into its rightful position, and secures its hold of the public. And when this is done, we find it is no stranger after all—that some twenty or thirty feet of shales, for instance, packed in with the base of our Lias, are really the representative of some great Alpine Limestones, which range from the Tyrol to the sources of the

Ganges, and which are only not as important as the Dudley Limestone because they have been as yet less studied and described."

It is sometimes stated that the work of correlation by the study of the distribution of organisms in the strata received about this time a severe check, not only because of the views already referred to, but also owing to the doctrine of colonies, as propounded by M. Barrande, and that this was especially the case with the Lower Palæozoic rocks. Mr. Salter's remarks show clearly that he, at least, was not unduly influenced by the wave of thought just then affecting the geological mind; and there is abundant evidence in the many papers published about this time and subsequently on the Lower Palæozoic rocks of Wales to show that though the prevailing views were given due consideration they did not in the least prevent the facts obtained being always fairly stated and supported.

In regard to Life Zones, which it has been stated were then particularly neglected as being objects of distrust, I need only say that so far as the Welsh rocks were concerned from the very commencement of our work in 1863, the Life Zones were clearly indicated, the range of each species was given, and the organisms supposed to be most typical of the zones and most useful for purposes of comparison were always carefully mentioned. As evidence bearing on this point I need only quote the following passage from my paper, "On some undescribed Fossils from the Menevian Group," in the Quart. Journ. Geol. Soc. May, 1872, pp. 180, 181: "During my researches at St. David's I have, from time to time, endeavoured to note the range of the genera and species as they were discovered; and the results have been given in the several tables published in the Journal of the Geological Society and in the British Association Reports. I have not, however, been able to obtain much evidence by this means to support the theory of colonies propounded by the eminent palæontologist, M. Barrande; but several very interesting facts have been noted, which it might be well again to refer to. The Brachiopods here, as in other formations, have a greater range than any of the other fossils, the same species extending in some cases through the whole Cambrian series. The sponges come next; for *Protospongia fenestrata* occurs in the Longmynd group, in the Menevian group, and again in the Upper Lingula flags, to the base of the Tremadoc rocks, where it was found by me a few years since when examining these rocks in North Wales. These, therefore, continued to live on during the deposition of from 8,000 to 10,000 feet of strata. None of the other Menevian species have any considerable range; and but very few of the genera pass beyond the Menevian boundary. Out of ten genera of Trilobites, one only, the little *Agnostus*, passes upwards; and not one species out of the whole number, in all twenty-nine. Indeed, the range of all the species is very limited; and each one seems to mark a special zone, where it flourished for a time and then disappeared, perhaps to be followed by others of the same type but never to re-appear. The Crustacea are, therefore, in these earliest rocks, the surest indices of the age of the strata, and the best guides

in defining the several zones; for the more perfect the forms and the higher the development, the less likely are they to have a great range."

Though Trilobites were found by us to be of greatest value in defining and correlating the zones in the Cambrian rocks, in succeeding sediments Graptolites and other organisms have proved of equal value. Sometimes it so happens that the forms which appear to be the most typical of an horizon in one area are entirely absent from another geographically not far distant; but in such a case, unless it can be shown that the physical conditions must have varied sufficiently to have affected the whole fauna, there are usually evidences of a sufficient number of the associated organisms present to enable the zone to be easily defined.

In working out zones it is necessary, therefore, to register with care all the forms which occur with the so-called zonal fossils, and also the evidences in the strata of the physical conditions prevailing when the sediments were accumulating.

(*To be continued.*)

VII.—The Primitive Boulders of the Yorkshire Coast and their Lessons. A Reply to Two Critics.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

I CANNOT sufficiently welcome the two letters devoted to myself in the July Number of the Geological Magazine; and I only hope Mr. Harker and Mr. Deeley will continue to face the issues between us, and not be content, as others have been, with fulminating more or less testy protests, and then retiring from the field.

Mr. Deeley objects to my statement that the tendency of the most philosophical writers on geology is to go back from the scholastic formula of Uniformity enunciated by Lyell and Ramsay to more inductive reasoning. With the writings of Suess and Lapparent, of Spencer and of Prestwich, before me, all of them veterans of the first class, I cannot either understand or appreciate Mr. Deeley's protest. Perhaps he means that the geological world is limited to English official geologists; most of them scholars of Jukes and of Ramsay, who naturally echo their masters' views. He will not expect me to agree with this delusion.

Turning from this wide issue to the narrower one of ice-sheets, I must again emphatically say that English geology is making itself ridiculous in the eyes of men trained as mathematicians and physicists by some of its professors habitually appealing to causes and to dynamical forces whose competence has not been proved or even shown to be consistent with the laws of matter. That ice moves as a plastic body has been abundantly proved by experiment. That moving thus it can travel over hundreds of miles of level country, or up and down great hollows like the Baltic and the North Sea, without an adequate *vis a tergo*, is incomprehensible to me. That such a *vis a tergo* can only, in the case of such ice-sheets, be

obtained by postulating a considerable slope to the ice surface is equally plain and equally admitted. How this slope is to be obtained, however, no one has yet explained, nor can I see how it could exist without burying every available land surface in Scandinavia, in the Laurentian Highlands, etc., etc., under deep ice. If the land surfaces were so buried it is impossible to understand whence the boulders could be derived, for they only come from exposed rocks, and to explain how it is that the higher parts of the Dovrefelds, etc., are not ice-marked. These are merely samples of the many difficulties which many inquirers have raised, and which I have tried to condense and focus in my recent books. These books, not having been written by an official geologist, and therefore lacking official inspiration, have probably not been read by my critics. Perhaps they will favour the readers of the GEOLOGICAL MAGAZINE with some adequate reply to them now.

But I must not content myself with *a priori* arguments, unanswerable though they may be. I want to ask my two critics how an ice-sheet in the North Sea is consistent with the splintered and pinnacled Lofoden Islands?—a question Matthew Williams long ago asked, and which has been strongly urged in a long letter I have received on the subject from Professor Bonney; or with the facts so eloquently put forward by Pettersen, the most competent observer who has written on the geology of North Norway, and who has shown that the inland ice of Northern Scandinavia did not even reach the string of islands lining its western coasts, much less invade and cross the North Sea. It is no use adopting the attitude of the ostrich towards facts like these. The ostrich is a very poor geologist, although some people think that he can thrive on boulders and gravel.

Again, if a Scandinavian ice-sheet reached Great Britain, how is it there are no boulders here from the western coasts of Norway at all? How is it that the few boulders which have been recognised as Scandinavian by Scandinavian geologists, who know their own rocks well, come not from Western Norway, but from the famous "Viken"—whence the Vikings got their name, and whence they sailed; and that in order to reach Northern England on the back or under the foot of an ice-sheet, that ice-sheet must not only have meandered like a serpent and ignored the lines of least resistance, without any assignable cause, but have cut right through and across the main ice-sheet which was presumably being shed in sporadic fashion by the great Dovrefelds? The whole position is so grotesque, when brought face to face with elementary facts, that I can only explain the logic of its champions on the supposition that the ice they appeal to is not frozen water but composed of brain dust.

One of my critics thinks he disposes of me by the statement that the so-called glacial beds of East Yorkshire are not heterogeneous masses of mixed mud, sand, clay, and gravel, but are assorted and sifted. Of course they are, and that is why these beds have nothing to do with glaciers or with ice in any form. Every moraine and

every ice deposit known to myself, except in some very local cases, is a heterogeneous mass, and is not assorted in this way; and human ingenuity has hitherto been baffled in trying to show how a great moving mass of very nearly rigid ice can sift sands and gravels and tough clays apart from each other and deposit them successively in the way these beds are laid down. Of course, if we go to the moon for our cheese instead of to some farm, where we can examine the process of making it step by step, we can postulate anything as to the process, but the result must be moonshine and nothing but moonshine!

Lastly, as to the provénance of the Yorkshire boulders: here, unfortunately, we differ absolutely about the facts. I have spent months on the coasts of Yorkshire and East Anglia, and have examined hundreds of boulders there, but I am bound to say I have never had the luck to find an unmistakable Scandinavian one.

There are vast numbers of boulders from the sandstones and the limestones of the Carboniferous series, and a large number from the basaltic and other dykes which cross and permeate those beds. Mr. Lamplugh, who has collected and tabulated hundreds of the boulders, says that those from the Carboniferous beds, including the dykes, form about ninety per cent. of the whole. I do not know anyone who has brought these boulders from Scandinavia. Nor do I know anyone who has ventured to suggest that the Oolitic, Liassic, and Cretaceous pebbles (which I have collected in considerable numbers) have come across the sea either. These latter everybody known to me attributes to the local beds. As to the Carboniferous boulders and their parentage, Mr. Lamplugh says: "With the definite and well-known trail of the Shap granite and Brockram erratics to guide us, we need feel no uncertainty as to the quarter whence the Carboniferous rocks have been derived. It is clearly the elevated region lying to the north-westward, 80 or 100 miles away, which has been the main contributor, and the route must in most, if not all cases, have been down Teesdale, and thence south-eastward along the coast."

Let us put aside all these admittedly English boulders, therefore, and limit ourselves to the primitive stones, which in the various collections made by Mr. Lamplugh formed respectively 3·4; 2; 5·7; 2; 3; 4; and 1 per cent. only of the whole.

It was these primitive boulders only which were sent for examination to Mr. Harker. Of them he says, "that the bulk of the specimens selected and submitted to him, of granitic, gneissic, and other crystalline rocks, might have been derived, so far as their individual character is concerned, either from Scandinavia or from the Scottish Highlands." This is assuredly a very important admission; made by Mr. Harker, not when engaged in a polemic with a man of Gath like myself, but when calmly summing up the evidence in the Transactions of the Geological Society of the West Riding of Yorkshire, new series, vol. xi.

Among the boulders just named are some of Shap granite, which are unmistakable, and others which are apparently derived from the

altered beds in contact with the Shap granite and from the Cheviots. Notwithstanding this concurrent evidence about the British derivation of the immense proportion of the boulders, Mr. Harker proceeds to argue, apparently on purely fantastic grounds, that the primitive boulders which *may have* come from Scotland really came from Scandinavia. He says that "the movements of the ice and the consequent directions of transport render this conclusion probable." This is assuredly putting aside empirical methods in favour of *a priori* and fantastic ones with a vengeance. Let us translate the argument into a syllogism: "Because more than nine-tenths of the Yorkshire boulders, including a great many primitive ones, are known to have come from the north-west, *therefore it is probable that the stones of doubtful origin found among the other tenth came from the north-east.*" Could he or I put an inconsequent argument more clearly?

There still remain a few boulders—*a very few*—which, so far as our present evidence goes, were apparently derived from Viken, in Norway; but even here Mr. Harker speaks with a dogmatism which is unusual in science. When we remember how long it took to discover the rock *in situ* from which the picrite boulders in Anglesea were derived, it is a very unsafe thing to assert dogmatically that a particular kind of crystalline rock *does not occur* in any part of Cumberland or Scotland, and must have come from Norway. I have the authority of one petrologist, quite as distinguished and more experienced than Mr. Harker, who is as sceptical as I can be about these *ex cathedra* judgments. It is noteworthy, by the way, as Mr. Harker admits, that while boulders of augite porphyry like that found at Laurveg have occurred on the Yorkshire coast, none have occurred there of the elæolite syenites which are associated with the augites in Norway.

But granting that some of these stones may have come from Norway—

A distinguished Norwegian geologist, belonging to the Geological Survey of that country, who wrote a paper in the Quart. Journ. Geol. Soc. on the East Anglian boulders, tells us that out of the many he saw only two seemed to him to be of Norwegian origin.

But let us turn to Mr. Harker himself. In his appendix to Mr. Lamplugh's second and third papers he only mentions two as similar to the augite syenites of Southern Norway; to these he adds two more in a subsequent paper. He also mentions two boulders of saussurite gabbro whose provénance seems to be equally established as from the same district; and this is all. If this be all, Mr. Harker has assuredly been making a voyage to one of Swift's regions of cloudland when he speaks of hundreds of Scandinavian boulders as having been found in as many yards of the Yorkshire coast. As a matter of fact, those he has described amount to six, all told; and to explain these six boulders he would fill up the North Sea with ice and then make it travel by a labyrinthine path which might have puzzled the Minotaur himself. I prefer to think that his six boulders, if really Norwegian, were brought by another

agency, and very probably by some ship—either by a Viking, whose countrymen used stones for anchors; or as ballast, as Mr. Hughes has seen other primitive boulders scattered on the coast of Norfolk. What I object to most emphatically is the continual manufacture of these gigantic postulates on the most fragile evidence by men whose work and gifts give them a wide audience.

REVIEWS.

I.—A Manual of the Geology of India. Chiefly Compiled from the Observations of the Geological Survey. Stratigraphical and Structural Geology. Second Edition, revised and largely re-written by R. D. Oldham, A.R.S.M., Superintendent, Geological Survey of India. Published by Order of the Government of India. 8vo. pages i.–xxiii. and 1–543. With several Plates and Woodcuts, and large Geological Map. Calcutta and London, 1893.

THE first edition of the "Manual of the Geology of India," published in 1879, consisted of two thick Parts or volumes, and a large map, by H. B. Medlicott, Superintendent, and W. T. Blanford, Deputy Superintendent, of the Geological Survey of India. This was followed in 1881 by Part III., on the "Economic Geology," by V. Ball, Officiating Deputy Superintendent; and in 1887 by Part IV., "Mineralogy," by F. R. Mallet, Superintendent of the Geological Survey of India.

The Parts I. and II. above-mentioned were carefully reviewed in the Geological Magazine, Decade II. Vol. VII. 1880, pp. 79–85 and 127–134. The important conclusions arrived at by Messrs. Medlicott and Blanford, from the geological researches made and recorded by themselves and their colleagues in the Survey, were noticed in detail in the review alluded to above, and were shown in classified tables taken from the "Manual," especially as to the successional formations, severally in "peninsular" and "extra-peninsular" India, with their approximate thicknesses, characteristics, geographical range, local types, and foreign equivalents, as far as then known.

The labours of the Survey since that time (1879) have been continuous and successful in many directions, as its rich and well-conducted "Palæontologia Indica" (many volumes in Series 4, 9, 10, 12, 13, and 14; with an Index, 1892, to the whole issue), and its "Memoirs" (vols. xviii. to xxiv.), fully prove.

In the title-page of this new Number of the "Records" (the "Manual of the Geology of India—stratigraphical and structural—second edition, revised and largely re-written, pp. 543, with numerous tables and geological maps. Royal 8vo. half-calf, 1893. 16*s*."), unfortunately, the names of the original authors have been omitted,—apparently by inadvertence, we must suppose, for one of them is mentioned at page *x*. as having assisted in the preparation of this second edition. This omission is greatly to be regretted.

In a prefatory note the Director of the Survey explains why this new edition was unavoidably delayed, and why he "accepted Mr. R. D. Oldham's offer to prepare a fresh issue" of the book "accordant with our progressive Survey of the Empire."

In this new edition, instead of describing the geological features and conditions of separate districts on a geographical plan, the new arrangement takes the formations of the two (peninsular and extra-peninsular) regions together in their chronological order. Thus the two tables at pages 82 and 83 of the GEOL. MAG. 1880, have to be taken together. Some corrected determinations of the true age of certain groups of strata allow of this new plan being adopted with advantage. For those parts of the country where the Survey has not been able to add any particulars, the text "has been allowed to stand practically as in the original publication"; but revised and condensed. Some alterations, on account of advancing knowledge, have been made where necessary. "In the Table of Contents, the portions in which the First Edition has been taken as the basis of the text are distinguished by a different type from that which refers to portions which are new or have been entirely re-written." Judging from the appearance of the new among the old headings, the proportion of the new to the old matter is about 9 to 22.

The first paragraph in Chapter I. is certainly re-written, but is rather longer than at page ii. in the first edition. The rest of the chapter confines itself mainly to the Physical Geography, without so much introductory and general classificatory matter as was given in 1879. Chapter II. shows that the metamorphic and crystalline rocks are now better known. The non-fossiliferous older sedimentary rocks are still referred to some "Transition" series or systems (Chap. III.)

The "older palæozoic" (Vindhyan, or Cambro-Silurian, for the upper, and Cuddapah for the lower) systems, both in the peninsular and the extra-peninsular areas, and including indications of Devonian in Thibet, and Silurian in Burma, are dealt with in Chapters IV. and V. The Carboniferous and Triassic rocks of extra-peninsular India (the Salt-Range, Kuling, Simla, Kashmir, etc.), with possible glacial beds, come into successional order here (Chap. VI.). The important Gondwána system succeeds (Chapters VII. and VIII.); with the Coal-beds of Damuda, Rániganj, etc., with their interesting fossil flora, fishes, and reptiles. The correlation of these formations with others in Australia and South Africa is carefully reproduced. The Lower Gondwána comprises stages from Carboniferous to Trias; and the Upper Gondwána is Jurassic. The marine Jurassic strata of Cutch, Western Rájputaná, Spiti, Hazára, etc., are found in Chap. IX.; and the marine Cretaceous beds of the Peninsula, in Chap. X. The affinities of the latter with extra-Indian Cretaceous formations is of considerable interest; so also the relation of the great Trappean formation of the Deccan to the same series and to the Eocene volcanic rocks of the Himálaya, somewhat condensed from the first edition. The extra-peninsular Cretaceous rocks are briefly treated, with some new notes, in Chap. XII.

The Tertiary strata of the Peninsula (Chap. XIII.), and of the Himálaya (Chap. XIV.), have been carefully re-arranged, with new information on some points. The great and extensive Nummulitic Limestone (Eocene) comes into this part of the series (the reference "Nummulites, cretaceous, in Balúchistán, 291," in the Index is a mistake; no *Nummulites* are really present). The extraordinary fossil Mammalian Fauna of the Sewalik strata, and their associated land and fresh-water shells, appear in their place as belonging to the Upper Tertiary in Chap. XIV. The Laterite, the Pleistocene, and Recent deposits, and the features and composition of the great Indo-Gangetic plain, follow with some additional knowledge in Chapters XV., XVI., and XVII. Chap. XVIII., on the Origin and Age of the Himálayas, and Chap. XIX., on the Geological History of peninsular India, are newly arranged and freshly written.

Besides some 27 woodcuts, in the text (mostly new), there are 16 plates (not numbered) of fossils, "phototyped" from either some re-arranged figures of the former plates, or specimens different from, but more or less similar to, those figured in the previous plates,—also a fine view, from a photograph, of the snow-capped Simvo (22,300 feet high) in the Himálaya,—a map of the Hill-ranges of India, modified from the former map,—a map and plans of the Volcanoes of Burma and Bay of Bengal,—a map of the Indo-Gangetic Alluvium,—a plate of sections of the Himálayas and Sub-Himálayas; also a good map of the Himálayas,—and a new geological map of India, dated 1891. Moreover, a useful "Geographical Index of Indian localities" fills 30 pages.

This book cannot but prove useful to those who wish to enquire into the structure and physical history of India and adjoining territories. Some notion of the characteristic fossils can be got from the figures; but they are far inferior to the plates in the first edition; and so indeed is the printing and general finish of the volume. The Index is faulty; many points are poorly treated; for instance, Baluchistán does not take a place in the alphabet, but appears incidentally, once with a wrong page, and once with a palæontological mistake (noticed above); and Nagpur is omitted altogether, though an important centre of geological facts both physically and historically.

When the next edition is required (it may be soon, with advantage), better paper and type, a more exact style of printing scientific and technical words, some improvement in other editorial points, and a more considerate title-page will make it compare more favourably with the first edition, and greatly enhance its value. T. R. J.

II.—An Index to the Genera and Species of the Foraminifera. By Charles Davies Sherborn. Part I. A to Non. Smithsonian Miscellaneous Collections, 856. 8vo. City of Washington. 1893.

AMONG the many minute organisms in the sea are those which influence the features of the sea-bottom, by either local or widespread accumulation of what we may call shell-matter. Sometimes this occurs to such an extent as to modify the fairway of ships;

and in past times it formed shoals and banks of extensive sea-beds, which have remained more or less consolidated as recognizable limestones among the various strata constituting the accessible parts of the Earth's crust. These microzoa are chiefly Foraminifera, of which we have heard and read much since the Expedition for the arrangement of the Atlantic Cable was reported in the Newspapers, and the subsequent scientific exploration of the "Challenger" was explained in various ways. For a century and more, however, before that period, scientists had known much of both the deep-sea life and the shore-life of organisms similar to what the deep-dredging brought up. Naturalists had already devoted labour and thought to the elucidation of these interesting objects; and descriptions with illustrations, often good, though rarely perfect, had accumulated in memoirs and books on the several kinds, genera, and species, of the Foraminifera. These little creatures were easily mistaken one for another, within certain limits of form and structure; hence names for them multiplied without clear distinctions, just as different observers in many cases took up really similar individuals and treated them with their own notions and new names. Especially this occurred with fossil forms, which offered a fascinating study, but required a previous knowledge of the results of former observations. To meet this difficulty, bibliographic lists had been appended to some of the best memoirs on the Foraminifera; but a far more exact catalogue of the authors and their works was supplied in 1888 by Mr. C. D. Sherborn; and was duly noticed in the Geological Magazine for January, 1889, pp. 34, 35. Feeling that still more was required to enable workers to see through this crowd of writers and manifold confusion of creatures, one and the same often bearing several different names, Mr. Sherborn continued to devote time and labour to an exhaustive bibliography, not only of the writers, but of every generic and specific name applied to the Foraminifera, recent and fossil. In 1889 the Smithsonian Institution, at Washington, D.C., U.S.A., generously undertook the publication of this enormous catalogue, or "Index to the Genera and Species of Foraminifera"; and the first half of this grand work, containing 10,000 names (from *A* to *Non.*), in 240 pages 8vo., dated "November, 1893," has been printed and published in a form befitting the liberality of that excellent and highly useful scientific Institution. Thanks to Mr. Sherborn's enthusiastic and painstaking labour, and his well-tried experience in bibliographic work, we can now congratulate Rhizopodists on having at hand a trustworthy guide through the nomenclatorial labyrinth which has grown up, from about 1565 (when the Italian naturalists were beginning to notice the abundant microzoa on their shores and in their strata) down to 1889.

Thus both former and present students of the Foraminifera will have the credit due to them fairly apportioned by priority; and many useful notes, falling in their right places in the Index, will aid future workers in solving doubts and difficulties. These wonderfully elegant, or quaintly shelled, microzoa are carefully studied in many countries; and of late years much has been added to our know-

ledge of their intimate structure by MM. Munier-Chalmas, Schlumberger, and others, in Paris and elsewhere; and quite lately J. J. Lister, of Cambridge, has communicated new and very important information about living forms to the Royal Society of London. The fossil species and varieties are always being presented in memoirs from one part of Europe or another, and occasionally from other regions. England is not behindhand in this study;—and of this fact, F. Chapman's elucidation of the Foraminifera in the Chalk of Taplow,—in the several Gault zones of Folkestone,—and quite lately in the Bargate-stone of Surrey, is sufficient evidence. T. R. J.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 20th, 1894.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "On Deep Borings at Culford and Winkfield, with notes on those at Ware and Cheshunt." By W. Whitaker, Esq., B.A., F.R.S., F.G.S., and A. J. Jukes-Browne, Esq., B.A., F.G.S.

The four borings are described in detail, so far as the specimens examined would permit; these were few in the case of Culford, but many from the other borings. The following is an abstract of the formations traversed in each:—

	Culford.	Winkfield.	Ware.	Cheshunt.
	ft.	ft.	ft.	ft.
Surface Beds	6	—	17	14½
London Clay	—	136	—	30
Reading and Thanet Beds	—	78	—	46½
Upper Chalk	383	329	? 183	? 273
Middle Chalk		177	227	? 237
Lower Chalk	143	219	173	183
Upper Greensand	—	31	40	44
Gault	73	264	166½	153½
Lower Greensand	32½	9	—	—
Palæozoic Rocks	19¾	—	35	29½
	657¼	1243	841½	1011

The interest of the Culford boring centres in its striking the Palæozoic floor at the small depth of 637½ feet; but the age of the slaty rocks cannot be determined. Although only 20 miles east of Ely, no Jurassic rocks exist, and the Lower Cretaceous series is only about 32 feet thick, the beds differing greatly from those of Cambridgeshire, but resembling those of the same age in the Richmond boring.

The Winkfield boring (3½ miles W.S.W. of Windsor) is remarkable for having been successful in obtaining water from the Lower Greensand, and for the great depth (1243 feet) to which it was carried for this purpose, the Gault being unusually thick.

The boring at Ware is now for the first time described in detail, and former accounts are corrected from specimens preserved by the New River Company. By this means, and with the assistance of Mr. W. Hill, the authors are able to give a fairly complete account

of the rocks and to determine the limits of the divisions of the Upper Cretaceous series. They deny the existence of Lower Greensand at this locality.

Of the boring at Cheshunt a more complete account is now given, based on information and specimens supplied by Mr. J. Francis, the Engineer of the New River Company.

The paper concludes with a tabular view of all the borings in the East of England, showing the level below Ordnance datum at which the Palæozoic floor occurs in each.

2. "The Bargate Beds of Surrey, and their Microscopic Contents." By Frederick Chapman, Esq., F.R.M.S. (Communicated by Prof. T. Rupert Jones, F.R.S., F.G.S.)

This is an attempt to correlate the Bargate Beds of Guildford and its vicinity with the members of the Lower Greensand as known elsewhere in the S.E. of England.

(1) The strata at Littleton quarry, near Guildford, are described in detail; the *remanié* fossils, Oolite ironstone, and other material derived from older rocks are noticed; the abundant occurrence of Ostracoda and Foraminifera in a particular clay-band is noted, and the method adopted for getting them free from the matrix is described. The residuary minerals left from the washed sand of this clay-band, and comprising zircon, rutile, tourmaline, kyanite, quartz, felspar, and glauconite, have been carefully studied and described for the author by Dr. W. F. Hume, F.G.S., who states that the minerals present are of the same size as those from the Bagshot Sands and three times as large as those from the Chalk-marl of the Isle of Wight. The constitution of the compact Bargate Stone, with its sponge-spicules and silicified shell-structures, is described in detail; and a rare Corallina and numerous arenaceous Foraminifera are noticed.

(2) The Bargate Series is well shown, along the lane crossing the hill below St. Martha's Chapel at Chilworth, with its pebbly beds, clay-seams, limestone, and sponge-beds. Dr. Hinde's descriptive notes on the sponge-spicules are given. Some detrital fragments of fossiliferous Oolitic rock described as of Jurassic age occur in these Neocomian strata, and are comparable with some of the material obtained from the deep boring at Richmond, Surrey, and probably derived from the old Jurassic ridge to which Godwin-Austen formerly made reference. The author has found evidence in this neighbourhood of the Folkestone Sands lying unconformably on the Bargate Beds.

The clay-beds noticed by Dr. Fitton at Holloway Hill, Godalming, the author refers to the Bargate series. South of Dorking, also, Mr. Chapman found sand and clay of this series on the Horsham Road.

The Ostracoda and Foraminifera found abundantly in some of the Bargate Beds in Surrey are then described in detail. Of the former there are 20 species and varieties, 7 of which are new; 9 have been previously described from Cretaceous strata, whilst 4 are Jurassic forms. Of the Foraminifera there are 139 species and varieties. Of these, 11 are described for the first time. There are besides

107 which have hitherto been unrecorded from beds of Neocomian age. The following 10 species and varieties have been known previously only from recent deposits, viz. :—*Haplophragmium foliaceum*, Brady; *Virgulina subdepressa*, Brady; *Ehrenbergina pupa* (d'Orb.); *Polymorphina sororia*, Reuss, var. *cuspidata*, Brady; *P. oblonga*, Will.; *P. regina*, Brady, Parker, and Jones; *Discorbina Bertheloti* (d'Orb.); *D. concinna*, Brady; *D. Vilardeboana* (d'Orb.); and *D. araucana* (d'Orb.). The large number of forms new to the Neocomian fauna is undoubtedly due to the fact that the deposits of the Bargate series belong almost exclusively to the "Laminarian" and "Coralline" zones. Taking into consideration the facts that 23 per cent. of the forms recorded are almost peculiarly Neocomian types, that these added to known Cretaceous and Tertiary species amount to 122, or 87 per cent. (the latter additions probably being due to the circumstance that the Neocomian strata have not been so extensively examined in regard to their rhizopodal fauna as might have been desired), it is extremely probable that the microzoic fauna of the Bargate series is almost entirely, though not quite (since we have a few Jurassic species present), indigenous to the deposit.

In conclusion, the author states his indebtedness to Prof. T. Rupert Jones, F.R.S., and Prof. J. W. Judd, F.R.S.; to Dr. W. F. Hume, F.G.S., Dr. G. J. Hinde, V.P.G.S., Dr. J. W. Gregory, F.G.S., and Graf Solms-Laubach; and to George Murray, Esq., F.L.S.,—for valuable aid during the preparation of the present work.

3. "On Deposits from Snowdrifts, with Special Reference to the Origin of the Loess and the Preservation of Mammoth-remains." By Charles Davison, Esq., M.A., F.G.S.

When the temperature is several degrees below freezing-point, snow recently fallen is fine and powdery, and is easily drifted by the wind. If a fall of snow has been preceded by dry frosty weather, the interstitial ice in the frozen ground is evaporated, and the dust so formed may be drifted with the snow and deposited in the same places. The snowdrifts as a rule are soon hardened by the action of the sun or wind, and the dust is thus imprisoned in the snow. As the snow decays, by melting and evaporation, a coating of dust is extruded on the surface of the drifts, and, increasing continually in thickness as the snow wastes away, is finally left upon the ground as a layer of mud, which coalesces with that of previous years. The deposit so formed is fine in texture, unstratified, and, as experiments show, mica-flakes included in it are inclined at all angles to the horizon.

The author describes several such deposits both in this country and in the Arctic regions; and suggests (1) that the Loess is such a deposit from snowdrifts, chiefly formed when the climate was much colder, but still very slowly growing; (2) that Mammoths suffocated in snowdrifts are subsequently embedded, and their remains preserved, in the deposits from them; and (3) that the ground-ice formation of Alaska, etc., is the remains of heavy snowdrifts when the coating of earth attained a thickness greater than that which the summer heat can effectually penetrate.

4. "Additions to the Fauna of the *Olenellus*-zone of the North-west Highlands." By B. N. Peach, Esq., F.R.S., F.G.S. (Communicated by permission of the Director-General Geological Survey.)

New material obtained by the Officers of the Geological Survey has been placed in the author's hands, and as a result he is enabled to add information concerning the species of *Olenellus* previously described by him (*O. Lapworthi*); he also describes a new variety of this species, three new species of the genus, a new subgenus of *Olenellus*, and a form provisionally referred to *Bathynotus*.

A study of the remains described in the paper make it probable that the dispersal of the Olenellids was from the Old World towards the New.

5. "Questions relating to the Formation of Coal-Seams, including a New Theory of them; suggested by Field and other Observations made during the past decade on both sides of the Atlantic." By W. S. Gresley, Esq., F.G.S.

A number of new facts are described, and the bearing of these and of previously recorded facts upon the origin of coal is discussed, special reference being made to the Pittsburgh Coal. The author lays stress on the stratification of coal, the sharp line of demarcation between coal and underclays, the character of the plants in the underclays and their asserted root-nature, the existence of partings in such seams as the Pittsburgh Coal, which partings sometimes contain *Anthracosia*, and really separate the coal into distinct seams. He describes the occurrence of "rods" of vegetable origin whose exact nature is not known, which, with ferns, he suggests contributed largely to the formation of some coals. He maintains that the evidence points to the formation of coal on the floor of an expanse of water, by vegetable matter sinking down from floating "islands" of vegetation, which may have been of very large size, and enumerates cases of such "islands" or "rafts" of vegetation which have been described as existing in modern times.

6. "Observations regarding the Occurrence of Anthracite generally, with a New Theory as to its Origin." By W. S. Gresley, Esq., F.G.S.

After discussing Dr. J. J. Stevenson's theory of the origin of anthracite, the author describes the nature and mode of occurrence of the anthracites of Pennsylvania, and gives his reasons for concluding that the de-bituminization of coal was not produced by dynamic metamorphism during mountain-building but rather by previously applied hydrothermal action.

7. "The Igneous Rocks of the Neighbourhood of Builth." By Henry Woods, Esq., M.A., F.G.S.

In south-west Radnorshire (just north of Builth) there is an area of Ordovician and associated igneous rocks, surrounded on all sides, except the north-west, by Silurian beds; this is shown on Sheet 56 S.W. and S.E. of the Geological Survey map, and was described by Murchison. In this paper the author gives a map of the southern half of this area, and a description of the igneous rocks—andesites, andesitic ash, rhyolites, diabase-porphyrite, and diabase. The diabase-porphyrite is intrusive in the andesite, and the diabase in the Llandeilo Shales. The andesitic ash rests on the andesite, and

is overlain by the Llandeilo Shales. The author concludes that the andesites, andesitic ash, rhyolites, and diabase-porphyrite are of Lower Llandeilo age; and that the diabases are post-Llandeilo and pre-Llandovery.

8. "On the Relations of some of the Older Fragmental Rocks in North-west Caernarvonshire." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., and Miss Catherine A. Raisin, B.Sc.

In a recent paper on "The Felsites and Conglomerates between Bethesda and Llanllyfni, North Wales," it is argued that, in the well-known sections on either side of Llyn Padarn, a great unconformity separates the rocks into two totally distinct groups.

The authors of the present communication discuss at the outset the great physical difficulties involved in this hypothesis.

They further affirm, in the course of a description of the sections, which are most clear and afford the best evidence:—

(1) That the strike in both the supposed rock-groups is similar.

(2) That the same is true of the dips.

(3) That very marked identity of lithological characters may be found in rocks on either side of the alleged unconformity, specimens occasionally being practically indistinguishable.

(4) That in no case which has been examined can any valid evidence be found in favour of the alleged unconformity, and that in the one which is supposed to be the most satisfactory proof of it the facts are wholly opposed to this notion.

CORRESPONDENCE.

ON THE ALLEGED CONVERSION OF CHLORITE INTO BIOTITE.

SIR,—The discussion between Dr. Callaway and myself, on the above subject, has reached a stage beyond which I do not think it can be profitably carried.

My great difficulty in this controversy has been to know where to have my adversary. Hunting Dr. Callaway's theories, from paper to paper over the leaves of the GEOLOGICAL MAGAZINE, takes my memory back to certain sporting episodes in my life connected with the Indian Gazelle. These graceful but restless little creatures are constantly on the move, and object, in a provoking way, to stand still to be shot at. I hope I may be pardoned for saying that Dr. Callaway's theories display a similar unsteadiness under fire.

I understood the author, in his first paper,[1] to be stating a case of dynamo-metamorphism, and treated the matter from that point of view. Dr. Callaway replied plaintively that "for the past four or five years, I have been insisting that, in the Malvern crystallines, biotite has been produced out of chlorite by 'contact-action';"[2] and on the following page he added, "I think it probable that there is not a scrap of biotite in the crystallines of the Malverns which has been produced except by 'contact-action.'"

On reading these statements, which seemed precise and definite, I tried another shot. Alas! the bullet flew wide of the mark. The

[1] GEOL. MAG. December, 1893, p. 535. [2] *Ibid.* May, 1894, p. 217.

author writes[1]: "I never said that chlorite is changed into biotite by contact-action *only*. . . . . Chlorite is changed into biotite by contact action *plus* dynamic action."

I will only say in conclusion, that I do not see that the illustrations which Dr. Callaway has given in his July paper strengthen his case. If I understand him, he seems to think (to put the argument shortly) that because chlorite abounds where signs of shearing exist that the hydrous chlorite has been produced by shearing; and secondly, because he has observed cores of mica in the chlorite, that the mica has been produced out of the chlorite by contact-action. "The uniform appearance of mica," he writes, "where the shearing is great and where the granite veins are numerous, while it is nowhere seen where shearing and veins are absent, appear to demonstrate that these are the true causes of the generation of the mica."

I think all the probabilities of the case are opposed to this view. As I said in my last paper, all petrologists are ready to admit that dark mica is a very common product of the contact-action of granite intrusion in diorite; and I think that the subsequent more or less complete conversion of this contact mica into chlorite by aqueous agents that have found ready access to the rock along the lines of crushing and shearing is what one would naturally expect. That there should be cores of mica left in the secondary hydrous chlorite is in accordance with the petrologist's experience in his studies of the conversion of olivine into serpentine and of augite into hornblende. Dr. Callaway's theory involves the supposition that the production of hydrous chlorite should precede the gneiss of the mica; and that portions of the hydrous chlorite should escape unsinged from the burning fiery furnace of contact metamorphism that converted their fellows into anhydrous mica. These, and other difficulties enlarged on in my last paper, have not been met.

C. A. McMahon.

[This correspondence is now concluded.—Edit. Geol. Mag.]

CATALOGUE OF THE MESOZOIC PLANTS IN THE DEPARTMENT OF GEOLOGY, BRITISH MUSEUM (NATURAL HISTORY). THE WEALDEN FLORA, PART I. 1894.—A CORRECTION.

Sir,—In adopting the generic name *Nathorstia* for a new type of Wealden fern ("Wealden Flora," p. 145), I was not aware that the late Prof. Heer had previously made use of the same genus.

My thanks are due to Prof. Nathorst of Stockholm for calling my attention to Heer's genus *Nathorstia*, which was instituted in 1880 for the reception of certain fragments of Marattiaceous ferns from the Cretaceous strata of Pattorfik, Greenland (Flor. foss. Arct. vol. vi. 1882. Nachträge zur foss. flor. Grönlands, p. 5, pls. i. and ii.). I propose, therefore, to substitute the generic name *Leckenbya* for the fern described in the Catalogue as *Nathorstia valdensis*.

Cambridge, *July*, 1894. A. C. Seward.

[1] Geol. Mag. July, 1894, p. 320.